Communication and information exchange related challenges in mass casualty incidents: An integrative literature review

Timo-Pekka Palmu

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Timo-Pekka Palmu
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Laurea University of Applied Sciences **Abstract**

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Timo-Pekka Palmu

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The purpose of this literature review was to investigate challenges and to enable development of communication and information exchange between incident sites and target hospitals. The objective was to identify and describe the 1) knowledge and 2) issues related to communication and information exchange between the incident site and the target hospital.

The research questions of the study were used to define what relevant information was exchanged between incident sites and target hospitals and what were the communication and information exchange related challenges in cooperation between authorities.

Mass casualty management and the medical response are the primary focus of the health sector during a mass casualty incident. Communication and information exchange have been identified as the biggest challenges hampering the effective creation of situational awareness among first responders at the incident site and officials in the target hospitals. These challenges reduce the ability of the health sector to provide the best possible care for the patients involved in the mass casualty incidents.

This integrative literature review was conducted by doing a structured search in the electronic EBSCO and ProQuest databases. Thirty-six articles were reviewed and eleven articles with varying designs were included in the study. The findings from the primary studies were extracted, analyzed, categorized and synthesized by themes.

The main findings related to the information needs were preliminary alerting of the target hospitals to enable comprehensive preparations and providing real-time patient-specific information to support preparations for individual patients and the use of limited resources in the hospital. The biggest challenges related to the communication and information exchange were identified to be the fragmentation of used command and information systems resulting in incoherent response. The need for national guidance to define and ensure unified operating systems and procedures for all first responders involved in mass casualty incidents was also recognized.

The findings illustrate that local modifications to operational plans and command and communication systems are inadequate means to address current challenges. The need for support and guidance from national institutions and the need to increase and strengthen the cooperation of first responder organizations in all levels were highlighted. A lack of research addressing the interplay of information, communication and cooperation specifically between the incident site and the target hospitals was identified. It was recognized that the planning and training of an emergency response focus mostly on the response efforts and the organizations on the incident site and risks leaving hospitals out of the loop. This seems contradictory as the main objective of the emergency response is to reduce impacts of the incident and to save as many lives as possible and cooperation between emergency medical services and hospitals is crucial in that context.

Keywords: mass casualty incident, communication, information exchange, challenges, hospital

Contents

1 Introduction

All governments and local authorities have responsibilities to protect safety of their citizens and public health by preparing for emergencies and providing emergency relief during mass casualty incidents (MCIs) and other health crises. The Strategic Framework for Emergency Preparedness of World Health Organization (WHO) identifies the main principles and objectives for health emergency preparedness and for the emergencies and events that are caused by natural, technological and societal hazards. (WHO 2016, 1-4.)

Preparedness is the basis for effective mass casualty incident management meaning that risks and potential hazards are recognized by government and local authorities and community and required plans are made and appropriate legislation is enacted. Mass casualty incident management should entail all four phases of the disaster cycle including mitigation/prevention, preparedness/planning, response and recovery. Mass casualty management and the medical response are the primary focus of the health sector in mass casualty incident and these operations are conducted on the incident site and at the target hospitals. (Lomaglio, Ansaloni, Catena, Sartelli & Coccolini 2019; WHO 2011.)

Mass casualty incident related relevant skills and factors that contribute to the effectiveness of incident management, communication and information exchange in incident site include used communication strategy and skills and knowledge related to it like closed-loop communication and coordination of information. Skills and factors related to selected communication, reporting and information sharing methods include used electronical tools and systems and reporting procedures and schemes. All these factors and skills contribute to the creation of situational awareness (SA) in the incident site and to the ability to pass that information effectively and clearly forward to the target hospital. Communications has been defined to have the biggest deficiencies and problems during mass casualty incidents and often ultimately resulting to insufficient SA among responders at the emergency site and in the target hospital. These deficiencies in communications include absence of protocols and standardization of used information tools and systems, lack of fluent communication between responders and information gaps relating to poorly planned and coordinated interoperability. These weaknesses in communication and information sharing lead to defective collaboration and inability to provide the best care for the casualties. (WHO 2007, 24; Harmsen, Giannakopoulos, Franschman, Christiaans & Bloemers 2017a, 505-510.)

It has been demonstrated by several countries that investing to the development of preparedness provides basis for more effective response during emergencies and as a result reduces health impacts and other consequences of the emergency (Chungong et al. 2021, 157-

159). Mass casualty incidents require managing complex systems, dealing with various stakeholders and different types and stages of emergencies. The common problem is that emergency management systems are often fragmented, localized and lack interoperability. The novel and future emergency management systems can offer support for the execution of a response. (WHO 2016, 1-2; European Commission 2017, 22-27.)

WHO introduces in its Strategic Framework for Emergency Preparedness the need for implementation of emergency preparedness at all levels depicting whole-of-society approach. WHO highlights the need to increase collaboration and cooperation between all stakeholders and identification of local specific needs and gaps in readiness (WHO 2016, ix, 16).

The significance of early activation of MCI response and efficient need-based allocation of personnel and resources in the target hospital throughout the incident management to secure the best possible care for casualties was recognized in the study by Chen et al. (2016, 1464). The topic of my thesis is important for me professionally as two of my current areas of responsibilities in emergency department (ED) in Oulu University Hospital are preparedness planning and critical communications in the mass casualty incident context. The purpose of this thesis is to enable global development of communication and information sharing between responders on the incident sites and in the target hospitals which is critical for the creation of situational awareness and can be used in the development of cooperation between authorities.

2 Mass casualty incident

Mass casualty incident is defined by WHO as “an incident which generates more patients at one time than locally available resources can manage using routine procedures. It requires exceptional emergency arrangements and additional or extraordinary assistance” or as “any event resulting in a number of victims large enough to disrupt the normal course of emergency and health care services”. (WHO 2007, 9.)

Urbanization has been recognized as one of the biggest factors contributing to increase in mass casualty incidents and impacting the incident management capability of officials. In 2010 there were an estimated 13,677 MCI patients in the United States and 60.9% of MCIs occurred in an urban setting (see Figure 1). Between 2017-2021 there have been reported 263,430 MCI patients (0.16% out of all patients) in the United States and 68.2% of MCIs occurred in an urban setting. (ISO 22320:2018; NEMSIS 2021; Schenk et al. 2014, abstract.)

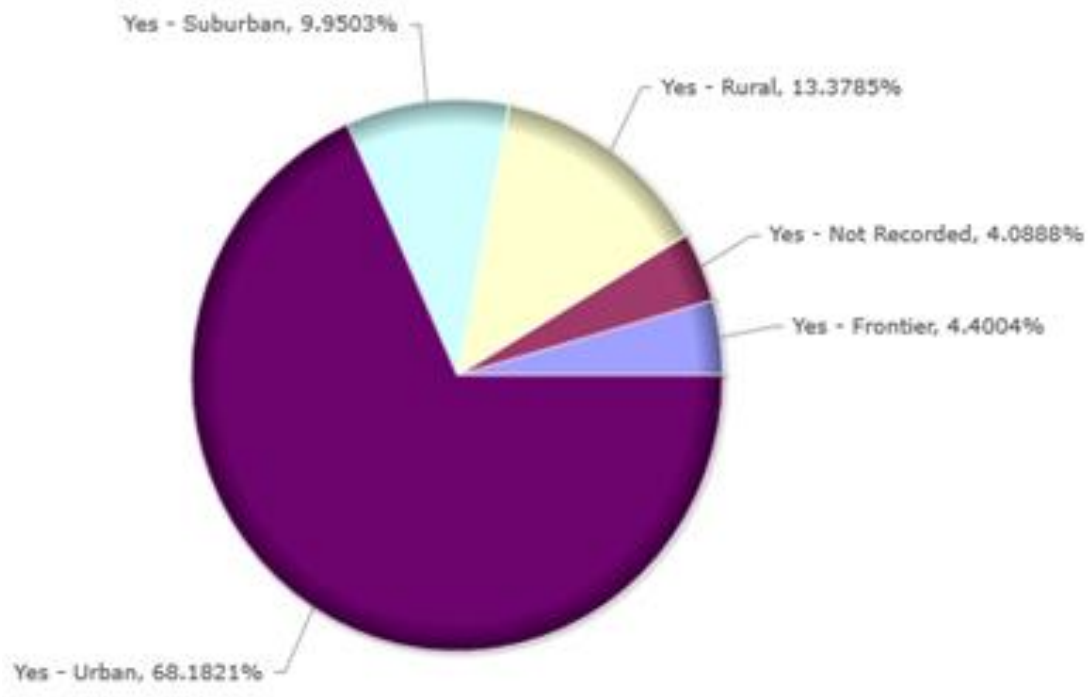

Figure 1: Distribution of mass casualty incident settings between 2017-2021 (NEMSIS 2021)

Important part of MCI management is conducting triage which means assessing acuity of each patient´s condition and prioritizing patients´ need for medical treatment. Several different triage algorithms have been developed. The most commonly used triage algorithm at the moment in the United States is Simple triage and rapid treatment (START). First responders conduct triage of patients and sort them into black (deceased), red (immediate), yellow (delayed) and green (walking wounded) categories. In 2017-2021 5.6% of MCI patients in the United States were sorted into red category and 8.3% into yellow category (see Figure 2). (NEMSIS 2021; Clarkson & Williams 2021.)

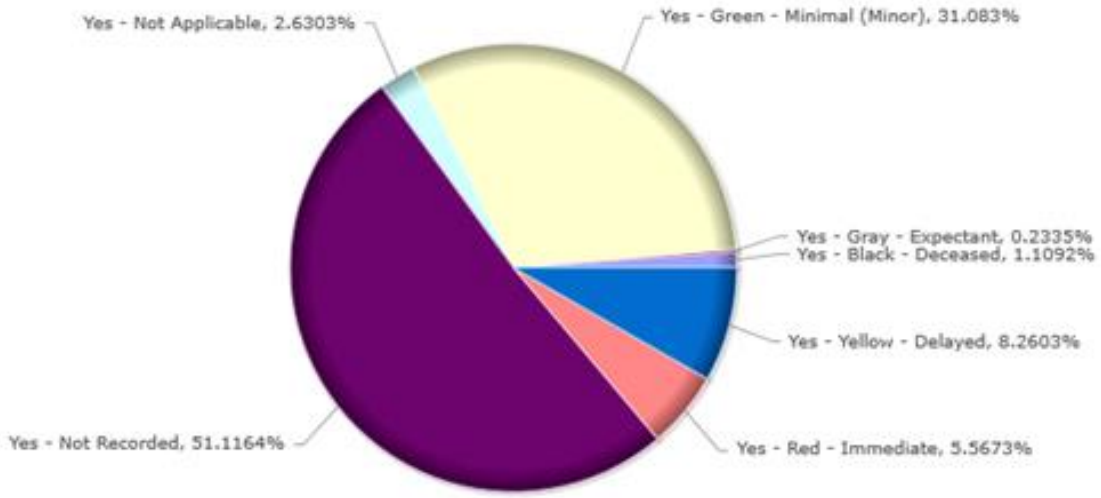

Figure 2: Triage category distribution of mass casualty incident casualties between 2017-2021 (NEMSIS 2021)

In their study Park, Shin, Song, Hong and Kim (2016, 450-451) used Korean Emergency Medical Services (EMS) database from six South Korean provinces and data collected between 2006 and 2012. They identified 362 EMS-assessed MCIs that involved 2,578 patients and used definition of six or more victims for EMS-assessed MCI classification. The statistics derived from NEMSIS (2021) and from study by Park et al. (2016) describe the challenge of defining MCIs. The availability of local medical resources varies which constitutes to differences in MCI classification globally. The most common cause for MCIs in the study by Park et al. (2016, 454) was identified to be road traffic accidents (89.0%).

2.1 Mass casualty incident management

In daily operations resources of authorities are targeted and dedicated to save and care individual casualties and patients. In mass casualty incidents these resources are distributed to save and care for the group of casualties. Mass casualty incident management is based on Incident Management System that provides national framework for interoperability and compatibility for local, regional and national capabilities. (DelValle Institute N.d.; Florida Department of Health. N.d., 34.) Emergency Operations Plan (EOP) is defined as the response plan of an entity that provides guidance for that entity´s responders for actions, tasks and management during emergency response (Florida Department of Health. N.d., 32).

As mentioned in the introduction WHO´s A Strategic Framework for Emergency Preparedness defines the main principles and objectives for health emergency preparedness. In the national level emergency preparedness should aim to achieve resilient health system that enables operational readiness to respond effectively to emergencies using whole-of-society approach

and taking into account One Health at the human-animal-environment interface. To achieve operational readiness a multisectoral response infrastructure based on existing capacities needs to be established, strengthened and maintained. Operationalizing emergency preparedness utilizes an iterative cycle to achieve this readiness and as one of key actions evaluation and taking corrective actions ensures persistent assessment and prioritization of emergency preparedness activities. (WHO 2016, ix, 4-7.)

The International Health Regulations (IHR 2005) were enacted in 2007 and since then WHO has actively supported State Parties in developing and strengthening IHR core capacities. WHO European Region submitted the action plan to improve public health preparedness and response 2018-2023 to 68th Regional Committee. This action plan is based on three strategic pillars that aim to build, strengthen and maintain States Parties´ core capacities, strengthen event management and to measure progress and promote accountability. (WHO 2019, abstract.) The Sendai Framework for Disaster Risk Reduction 2015-2030 is the framework of United Nations that aims to build disaster resilience into policies, plans and budgets at all levels (UN 2015, 9).

Situational awareness is defined in the study by Norri-Sederholm et al. (2016) as information and its interpretation. Furthermore they describe the flow of information to consist of three phases: understanding, creating the knowledge and decision making. Identifying critical information needs and setting up good information flow is crucial for creation of situational awareness and enabling efficient incident management and coordination of response efforts when working in mass casualty incidents. (Norri-Sederholm, Seppälä, Saranto & Paakkonen 2016, 74-76.)

ISO 22320:2018 sets guidelines for incident management like organizational structure, processes, resource management and cooperation in the field of emergency management. ISO 22320:2018 guides the organization to conduct planning for preparedness and response components like safety, incident management objectives, gathering relevant situational information, monitoring and assessing the situation, tracking and management of resources, communications and building the common operational picture. (ISO 22320:2018.)

2.2 Hospital incident command system

Hospital incident command system (HICS) is scalable, adaptable and flexible system that defines an organizational structure for incident management for hospitals enabling managing effectively threats and emergency incidents (California Emergency Medical Services Authority 2014, 4).

Hospital´s Incident Respond Command Center and Emergency Room´s management level need critical information from the emergency site as quickly as possible to begin the preparations

for receiving the patients and to create a situation awareness within the hospital. Hospitals´ ability to respond effectively to all incidents is crucial to the safety of patients and the ability of hospital to provide care for them. Hospital incident command system (HICS) utilizes standard format that also other responding agencies use during mass casualty incidents facilitating smooth transition to new organizational structure and efficient cooperation and coordination among all community response partners. HICS is based on a comprehensive all-hazards incident management strategy that utilizes fundamental elements like modular design, predictable chain of command, clear roles and team functions, adaptability, flexibility and scalability of the incident management system and common language to bolster interagency communication. (California Emergency Medical Services Authority 2014, 5, 70.)

Hospitals using HICS promote efficient and coordinated response with other responding agencies supporting consistence in all aspects of cooperation including accreditation of local incident management system. Maintaining situational awareness is important also in hospital during emergencies to enable timely response and using HICS promotes this by addressing the importance of information sharing in the planning processes. The emergency operations plan (EOP) introduces organizational guidelines for hospital response in emergencies. (California Emergency Medical Services Authority 2014, 6-7.)

The principles, features, strengths and weaknesses of Hospital Incident Command System are defined in the systematic review by Bahrami, Ardalan, Nejati, Ostadtaghizadeh and Yari (2020, 71-72). They describe that HICS provides framework for quick, effective, structured and organized incident response, guidelines for a response planning and coordination of response efforts within hospital and with other first responders, authorities and hospitals and guidelines for planning and implementation of emergency communications protocols and plans. The main factors promoting system efficiency were described as familiarity with the organizational system and structure, development and description of units and their duties based on hospital requirements, providing sufficient training of managers and staff and implementation of advanced communication technology to enable sharing of critical information. The main factors decreasing system efficiency were described to be differences in roles and job responsibilities in comparison to daily work, the incompatibility of HICS with the management structure of hospitals and the lack of management level involvement. (Bahrami et al. 2020, 73-74.)

2.3 Interoperability during mass casualty incidents

The Healthcare Information and Management Systems Society (HIMSS 2021) defines interoperability as “the ability of different information systems, devices and applications (systems) to access, exchange, integrate and cooperatively use data in a coordinated manner, within and across organizational, regional and national boundaries, to provide timely and

seamless portability of information and optimize the health of individuals and populations globally.” HIMSS (2021) also points out that architectures, application interfaces and standards of health data exchange need to enable accessibility for the health data for the whole chain of care, in all applicable settings and with all relevant stakeholders. (HIMSS 2021.)

Set interoperability standards provide common language and shared expectations that enable interoperability between systems and devices of different authorities. This improves the overall coordination of mass casualty incident and enhances the delivery of healthcare for casualties by providing base for timely, seamless and secure communication and information sharing. HIMSS (2021) recognizes processes, systems and individuals as parts of the health interoperability ecosystem and first responders, patients, hospitals, health systems and researchers as potential stakeholders within this ecosystem. All these stakeholders create, use and exchange health information and data creating information infrastructure that uses technical standards and is based on set local policies and protocols. (HIMSS 2021.)

European Commission adopted 2017 the European Interoperability Framework that provides guidance and recommendations for setting up interoperable digital public services. By utilizing this framework public administrators can improve management of interoperability activities, establish and enhance cross-organizational relationships, strengthen end-to-end digital service processes and secure interoperability efforts by ensuring legislation consistence. The European Interoperability Framework defines interoperability to consist of four layers: legal interoperability, organizational interoperability, semantic interoperability and technical interoperability. (European Commission 2017, 4-5.)

Relationships with other organizations and creation of common operational picture are defined in ISO 22320:2018 to be one part of incident management process and tasks. The importance of coordination and cooperation within own organization and with other stakeholders is emphasized. All stakeholders should share the same incident management process including 1) understanding roles and tasks of all responders, 2) the overall objectives of incident management, 3) the capabilities of other stakeholders and available resources and 4) assessment, planning and execution of response tasks. All stakeholders should expedite creation of a common operational picture by effective and proactive information sharing, clear and coordinated communication, continuous assessment and analysis of information obtained and joint decision-making process. (ISO 22320:2018.)

2.4 Impact of information sharing and communication

Cybersecurity and Infrastructure Security Agency (CISA) describes in National Emergency Communications Plan (2019) the Emergency Communications Ecosystem that is dynamic and multi-directional and includes various people, systems and functions that exchange

information. Emergency communications is defined to be the methods and means for sharing of relevant information to enable successful incident management. CISA recognizes the emergency communications as critical part of national ability for efficient respond during emergency events. CISA defines as four key emergency communications functions to be 1) reporting and requesting assistance, 2) incident coordination and response, 3) alerts, warnings and notifications, and 4) public interaction. (CISA 2019, ES-2, 1-9.)

In reference to National Emergency Communications Plan (CISA 2019) European Union Agency for Cybersecurity (ENISA) released the EU MS Incident Response Development Status Report in 2019. Both of these publications emphasize same aspects of incident response like enhancement of governance, coordination and leadership. They also highlight the development of emergency communications by implementing novel emergency communications systems, maintaining cybersecurity, conducting continuous risk assessment and improving interoperability through development of operational protocols and procedures and persistent training and exercises. (CISA 2019, AN-1, AN-10, AN-27; Taurins 2019, 9.)

Health information exchange (HIE) is defined by HIMSS (2021) to able clinical information sharing between separate healthcare information systems and provides access to clinical data securing efficient, equitable, timely and safe patient-centered care. The benefits of information sharing generally and during mass casualty incidents include better care management with access to patient´s health information, enhancement of administrative processes like coordination of care and reporting needs, increased patient safety and incorporation of non-traditional health data to provide better value-based care. (HIMSS 2021.)

Securing Health Emergency Learning and Planning (S-HELP) project of European Commission was aimed to develop a decision support system (DSS) to deliver a holistic approach and tool to healthcare preparedness, response and recovery. Decision support systems like S-HELP can be used to create an integrated framework for all phases of disaster cycle and to improve interoperability, coordination and emergency communications. (European Commission CORDIS 2017.)

Communication is defined in ISO 22320:2018 as a tool providing a common operational picture and enabling creation of credible reports of an incident. Clear communications between appropriate authorities are recognized as critical in all phases of disaster cycle. It is recommended to implement communication and skills related to it as an integral part of preparedness and to utilize planned communication protocols and procedures from the start of initial assessment of the incident. (ISO 22320:2018.)

The need for clear communications and the importance of standardized approach and protocols for reporting and patient handover during mass casualty incidents were recognized in the study by Harmsen et al. (2017b). They identify critical parameters to be included in the

handover report to be gender, age, mechanism of injury, assessed injuries, patient´s airway status, breathing, hemodynamic status and neurological status including neurological abnormalities. Reporting these parameters were set to allow proper assessment of the care needed and transfer of the responsibility of care. (Harmsen et al. 2017b, 9.)

2.5 Situational awareness

Creating incident related situational awareness is recognized as a critical component of efficient command and control at the incident scene. Communications related deficiencies yet still hinder the creation of situational awareness and management of response efforts. The rate of novel technology advancements keep outpacing the public community acquisition cycle and this emphasizes the need for public safety organizations to focus their development processes to most critical areas of public safety operating environment and to key technology areas. The need to identify mission-critical communications technology to improve command and control and situational awareness is highlighted. It is recognized that the public and information gained from social media sources needs to be utilized more effectively to enhance creation of situational awareness. (CISA 2019, ES-1, ES-2, 6.)

Creating and maintaining situational awareness is defined as a crucial part of HICS. It is emphasized that hospital personnel should also be familiar with their regional mass casualty plans and practices of other stakeholders. An early notification and sharing of relevant situational information to the target hospital is defined to be crucial for the activation of hospital´s EOP and efficient incident management within hospital. Pre-planned communication protocols are described to be important for efficient communication with other stakeholders at the incident site and maintaining situational awareness within hospital. (California Emergency Medical Services Authority 2014, 21.)

3 Study purpose, objectives and research questions

The purpose of this ILR is to enable development of communication and information exchange between incident sites and target hospitals that can be used in the development of cooperation between authorities. The objective is to define the 1) knowledge and 2) issues related to communication and information exchange between the incident site and the target hospital.

Research questions:

1. What relevant information was exchanged or transferred between incident sites and target hospitals?

2. What were the communication and information exchange related challenges in cooperation between authorities?

4 Methods

4.1 Study setting

My thesis was based on Laurea UAS´ Disaster Resilient Society -project proposal for the Horizon Europe, European Union´s research and innovation framework programme. The aim of the project proposal was to do research and develop and standardize the procedures of first responders and hospital officials in emergency and surge situations.

4.2 Integrative literature review

This thesis is an integrative literature review (ILR). The ILR is used to systematically analyze and summarize past research on specific field by drawing overall conclusions from previous studies. By conducting this analysis on past research, the gaps in the current research setting can be identified, future research needs defined, and theoretical and conceptual framework described. The ILR method allows combining of different research methodologies to create conception of the researched phenomenon. Different data sources like empirical and theoretical literature can also be combined when conducting an ILR. The ILR as a review method can be utilized to review theories or evidence or to define concepts of interest. Common challenges in conducting an ILR is analyzing data from various sources and constructing a synthesis of the findings. The integrative literature review consists of problem formulation, literature search, evaluation of data, data analysis and interpretation and presentation of results. (Whittemore & Knafl 2005, 547-548; Russell 2005, 1.)

Problem formulation begins with elaboration of conceptual and operational descriptions of variables to be reviewed and clear definitions of the problem and the purpose of the review. The conceptual definition describes abstractly the issue to be studied. The operational definition describes the measurement methods for the concept. In conducting an integrative literature review the operational definitions should not be defined too narrowly because this can threat the quality of findings and validity of the study. The operational definitions should not be too broad either as this can lead to ignoring significant study details and false interpretation of results. Clearly defined variables of interest and review purpose enable appropriate application of variables and extraction of relevant data from data sources. (Whittemore & Knafl 2005, 548; Russell 2005, 2-3.)

The two key steps in literature search phase are identifying the target and accessible population. The target population entails individuals or groups that are represented in the

integrative literature review. The accessible population includes all published articles and reports of the topic. For conducting the literature search a data collection tool is developed and relevant data to be collected is characterized. Clearly defined strategies for literature search will yield more precise search results enhancing the rigour of the review. To improve validity of the study the data collection should include adequate sampling meaning defining inclusion and exclusion criteria and reasoning for these, clear definition of review information like keywords and sources, presenting all selection biases and presenting a summary of demographics of the articles included in the study. All the decisions related to the sampling need to be justified and clearly documented in the method section of the review. (Whittemore & Knafl 2005, 548-549; Russell 2005, 3-4.)

Data evaluation phase of ILR consists of critical evaluation of the data elements or results and reliability of these findings. The threat to validity of the study in data evaluation phase is the ability of the researcher to maintain objectivity in methodology and results evaluation. (Russell 2005, 4-5.)

Presentation and reporting of an ILR includes introduction, methods, results, and discussion sections following PRISMA 2020 guidelines. A table or diagrammatic form can be used to present the conclusions of the ILR. The results of the ILR should cover integrity of the topic researched and present discovered implications for current practice and for future research. Threat to validity of the study in presentation phase include omission of relevant details or information relating to conducting the ILR. To reduce this threat, it is recommended to invest heavily on all details of the report. (Whittemore & Knafl 2005, 552; Russell 2005, 5; PRISMA 2021.)

4.3 Data search strategy

The used electronic databases included EBSCO and ProQuest. All the results of database searches were saved to open-source reference management software Zotero. The selection process of articles included scanning of titles and abstracts and evaluation of full texts of relevant articles. All reference lists of selected articles were inspected.

The modern healthcare systems rely on evidence-based nursing practices and standards build upon those that provide reliable research-driven data to improve patient care processes. By using a standardized format researchers can reflect the problem or the clinical issue, define good clinical research questions and find clinically relevant evidence by describing the specific patient problem, main intervention to be used, the main alternative to compare with the intervention and the outcome to accomplish or measure. The PICO format can be used for guided reflection process and to assist the formulation of good research questions. Other phases of the PICO process consist of identification of keywords for each PICO element, compiling of search strategy, executing the search, applying limiters to refine and focus your

results, review and selection of articles and determining the level of evidence. The careful selection of keywords is emphasized as they are key factors in driving the search strategy and improving the scope of the search. The PICO model of this thesis is presented in Figure 3. (Jensen N.d., 2; Fineout-Overholt & Johnston 2005, 157-158.)

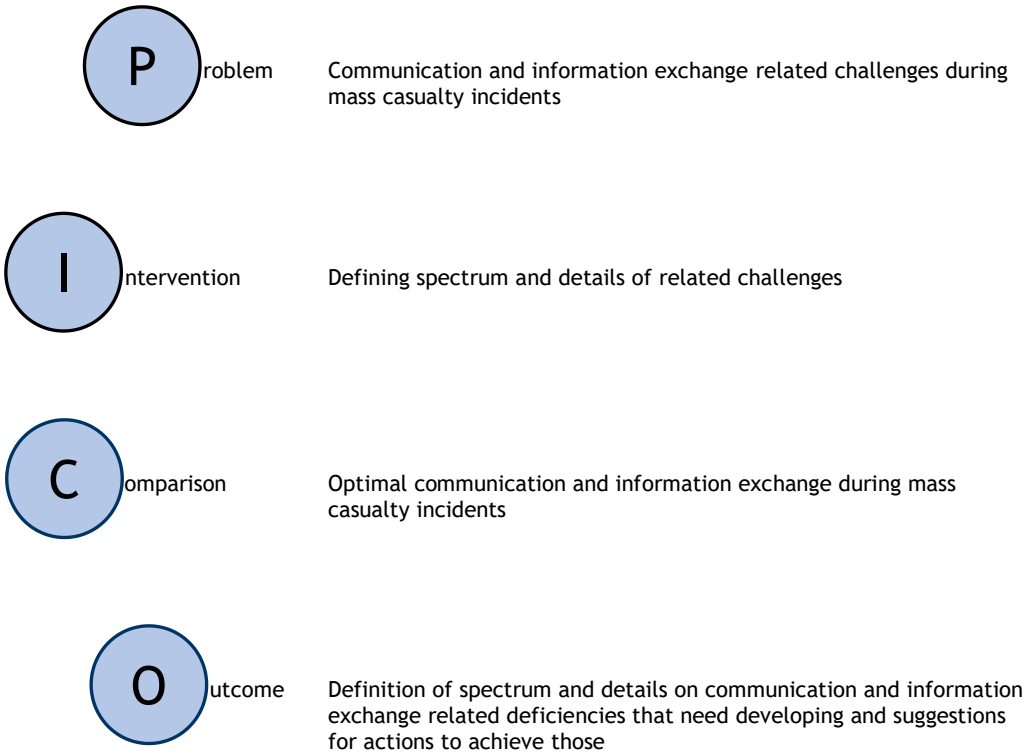

Figure 3: PICO model

4.4 Data collection

The selected search strategy was chosen in order to retrieve articles that address diversily problems related to communication and information exchange between incident sites and target hospitals. The first author performed database test searches and acquired guidance from the information specialist on how to set up keywords and on usage of different databases in March 2021. The first author performed initial database searches during September 2021-January 2022. Used search terms were chosen in accordance with the eligibility criteria presented below (see Table 1) and including aspects of 1) mass casualty incident, 2) communication, and 3) problems.

Inclusion criteria	Exclusion criteria
Articles published in English	Articles published in other languages outside English
Peer-reviewed original research articles	Studies other than research articles
	Studies not peer-reviewed
Articles published between 2012-2022	Articles published before 2012
Studies that address communication OR information exchange related issues during mass casualty incidents	Studies not associated with communication OR information exchange during mass casualty incidents

Table 1: Inclusion and exclusion criteria

The search was started from ProQuest database in March 2022 targeting search to "Anywhere" in text and adding limiters "Published between 2012-2022", "Scholarly Journals", "English", "Peer-reviewed" and using subject limiters: (patients; hospitals; information processing; decision making; efficiency; communication; emergency preparedness; emergency medical care; disasters, data processing; networks; information systems; casualties; classification; emergency services). The used ProQuest search sentence:

("mass casualty incident" OR "mass casualty event" OR mci OR "incident site") AND ("emergency communication" OR "information flow" OR "information transfer") AND (problems OR issues OR challenges OR difficulties)

The second database search was done with EBSCO using databases CINAHL with Full Text, MEDLINE and Business Source Elite and search was targeted to "AB Abstract". "Published between 2012-2022", "English", "Peer-Reviewed" and "Full Text" were used as limiters. EBSCO database search was done using the search sentence:

(mass casualty incident OR mass casualty event OR mci OR incident site) AND (emergency communication OR information flow OR information transfer) AND (problems OR issues OR challenges OR difficulties)

In the start of EBSCO database search data reduction process one duplicate article was excluded. In both database searches the titles and abstracts of the remaining articles were screened by the author (T-PP) as the first reviewer and the supervisor of the thesis (T-KA) as the second reviewer of the articles. After screening, discussion and consensus appropriate articles were included for this review. Full text of the remaining articles were read by both reviewers individually. After considering the inclusion and exclusion criteria, discussion and consensus relevant articles were included to the study. References of the selected articles were screened by the first reviewer (T-PP) and no appropriate references were included to the study. In summary the articles that were regarded scientifically qualified and relevant

were included to the study. Data reduction process is presented in Figure 4. Conducted database searches are presented in Table 2. Included articles are presented in table (see Appendix 1).

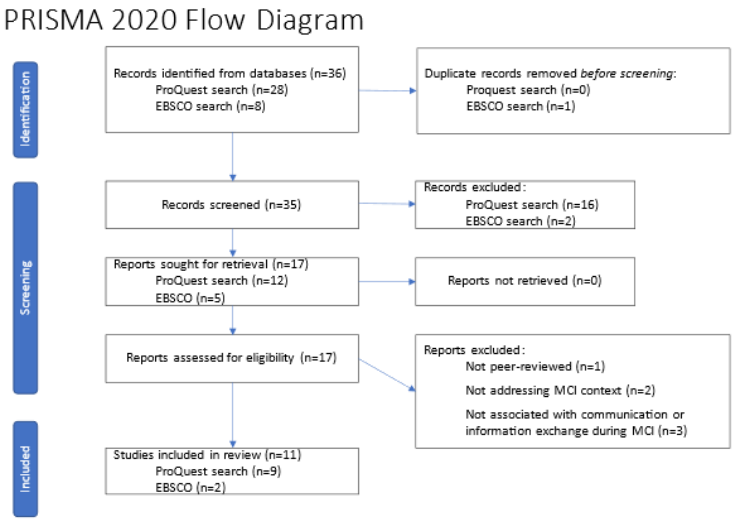

Figure 4: Data reduction process

Database	**ProQuest**	**EBSCO**	**TOTAL**
Published between	2012-2022	2012-2022	
Language	English	English	
Targeting search to	Anywhere in text	AB abstract	
Other limiters	Peer-reviewed Scholarly Journals Subject limiters: (patients; hospitals; information processing; decision making; efficiency; communication; emergency preparedness; emergency medical care; disasters, data processing; networks; information systems; casualties; classification; emergency services)	Peer-reviewed Full Text Used databases: CINAHL with Full Text, MEDLINE and Business Source Elite	
Search sentence	(“mass casualty incident” OR “mass casualty event” OR mci OR “incident site”) AND (“emergency communication” OR “information flow” OR “information transfer”) AND (problems OR issues OR challenges OR difficulties)	(mass casualty incident OR mass casualty event OR mci OR incident site) AND (emergency communication OR information flow OR information transfer) AND (problems OR issues OR challenges OR difficulties)	
Number of hits	28	8	
Number of removed duplicates	0	1	
Number of excluded articles after title and abstract screening	16	2	
Number of excluded articles after reviewing full-text articles	3	3	
Number of final selected articles	9	2	**11**

Table 2: Conducted database searches

4.5 Quality assessment

Different types of research designs have different criteria for quality. Quality assessment process of reviews is simpler than other research designs as the sampling frame is narrow and included studies usually have less variation in their research design. Quality assessment of the ILR is challenging due to large number of primary sources increasing the complexity of the study. Purposeful quality assessment of the ILR usually entails finding the balance between broad enough quality criteria and utilizing multiple specific quality evaluation tools. In this ILR the included studies consisted of four different methodologies and because of that four different evaluation tools were chosen for critical appraisal. The sampling frame is the primary factor influencing the quality assessment design of the ILR. In the assessment of an ILR with a broad sampling frame including both theoretical and empirical primary sources the focus should be on representativeness, authenticity, informational value and methodological quality of primary sources. (Whittemore & Knafl 2005, 547-550.)

Both reliability and validity are needed within the selected data search protocol of qualitative research to enable dependable and consistent gathering of research data. Reliability of the study describes consistency of measurement of a construct of interest. To define and demonstrate reliability of the study, it is needed to depict the connection between the search data and the results of the study. The researcher needs to describe the analysis process with adequate detail and by utilizing tables and appendices to elaborate and present these connections. (Elo & Kyngäs 2008, 112; Bhattacherjee 2012, 56.)

Validity depicts the interconnectivity of the construct of interest and the selected operational measure in the study. Theoretical and empirical approaches should be used in the validity assessment of the research design. Theoretical assessment of validity depicts the representativeness of a theoretical construct in a operational measure. Empirical assessment utilizes empirical observations to describe a relation between a given measure and external criterions. (Elo & Kyngäs 2008, 108; Bhattacherjee 2012, 58.)

When conducting an interpretive research like a review it is important to implement systematic and transparent approaches for data collection and analysis to express rigor in the quality assessment of the included studies. Critical Appraisal Skills Programme (CASP) can be used as a quality assessment tool to assess qualitative study, it´s results, relevance and trustworthiness systematically. (CASP 2018.) Strengthening the reporting of observational studies on epidemiology (STROBE) statement was utilized to enhance the quality and set a framework for reporting of observational studies included to an ILR (STROBE 2022).

The studies included to the ILR had different research designs requiring different quality assessment tools. CASP was used for quality assessment of the four included qualitative studies. STROBE statement was used for quality assessment of the four observational studies.

Quality assessment of the one included integrative literature review was conducted by using a modified JBI Global checklist for systematic reviews and research synthesis (JBI 2020). Quality assessment of the two included mixed method studies was conducted with QuADS (Harrison, Jones, Gardner & Lawton 2021).

4.6 Data analysis

Qualitative data analysis is done to systematically interpret and clarify abundant and diverse nonnumeric information by identifying and generating patterns and integrating them to more comprehensible forms (Averill & de Chesnay 2014, 1). Conducting rigorous data analysis and describing this process with sufficient detail is required to elucidate the trustworthiness of the study. A systematic analytic method should be implemented to the data analysis phase of an ILR to ensure unbiased and in-depth interpretation of primary sources. Data analysis phase of ILR includes compiling of data points collected and formulating an unified statement of the research problem. To achieve this the compiled data needs to be coded, categorized and summarized providing synthesis of the evidence. The methods to be used to improve validity of the study in data analysis phase include clear representation of assumptions made, identification of used interpretation rules and clear delineation of single-study based evidence. (Whittemore & Knafl 2005, 548-550; Russell 2005, 5.)

In their article Whittemore & Knafl (2005) present an updated methodology for ILR data analysis including data reduction, data display, data comparison, conclusion drawing and verification phases. Data reduction phase includes dividing the primary data sources into subgroups based on type of information, topic, setting, sample characteristics or chronology. Second part of data reduction phase is extraction and coding of data acquired from primary data sources and organization of data using a spreadsheet or matrix. In data display phase the extracted data is compiled and displayed in an appropriate form allowing comparison between primary data sources. Data comparison phase includes viewing of compiled data to identify themes, relationships and patterns. Data comparison phase requires critical analysis and creativity to recognize the important themes and connections in the data. Conclusion drawing and verification phase entails gradual elaboration of data divided into subgroups, connecting and generalizing descriptions of patterns and relationships, identifying commonalities and differences and constructing conclusions and conceptual models. Final phase of the data analysis is constructing overall conclusions and synthesis integrating all data from subgroups and defining the findings of the review. (Whittemore & Knafl 2005, 550-551.)

At first the results from the included studies that address research questions were extracted and listed. In the initial coding phase the extracted results from the included studies were organized to subgroups according to aligning characteristics of information. The extracted results were critically analyzed and connected on the basis of aligning topics and compiled in

the enhanced coding phase into four categories addressing converging aspects of 1) information needs, or 2) challenges in communication and information exchange. These four categories are presented as indexes and finally named with descriptive titles. The resulted categories were compared with the original extracted data from the included studies to verify the results and the data analysis processes. The connections between the individual included studies and the results are presented in the Table 3 and the Table 4. Data analysis processes are described in Appendix 6.

5 Results

This review describes the results of the included studies examining relevant information that is exchanged between incident sites and target hospitals and the communication and information exchange related challenges in cooperation between authorities. The initial search yielded 36 articles. ProQuest database search yielded 28 articles. After described data reduction process nine articles were included to the study. EBSCO database search yielded eight articles. After described data reduction process two articles were included to the study. References of all the selected articles were screened by the first reviewer (T-PP) and no appropriate references were included to the study. Eleven articles were included to the study and for the final analysis. Four studies were qualitative studies (Madanian & Parry 2021; Norri-Sederholm, Kuusisto, Kurola, Saranto & Paakkonen 2014; Tavakoli, Yarmohammadian, Safdari & Keyvanara 2017; Yang, Su & Yuan 2012), four observational studies (Allen, Karanasios & Norman 2014; Caglayan & Satoglu 2021; Lee et al. 2019; Urquieta & Varon 2014), two mixed method studies (Marres, Taal, Bemelman, Bouman & Leenen 2013; Tian, Zhou, Wang, Zhang & Li 2014) and one study was an integrative literature review (Holgersson 2016).

The included studies were versatile including a wide range of relevant information themes and communication and information exchange related challenges. These studies were analyzed and categorized according to the aligning themes. The comprised categories out of emerged themes relating to relevant information included 1) accident related information; 2) casualties related information; 3) transportation of casualties and other incident management related information; and 4) cooperation between incident scene and hospitals related information. The categories that were composed out of emerged themes relating to communication and information exchange issues included 1) challenges related to command system, cooperation, communication and operating procedures; 2) challenges related to communication infrastructure and equipment; 3) challenges in information handling; and 4) challenges related to personnel and incident site (see Figure 5).

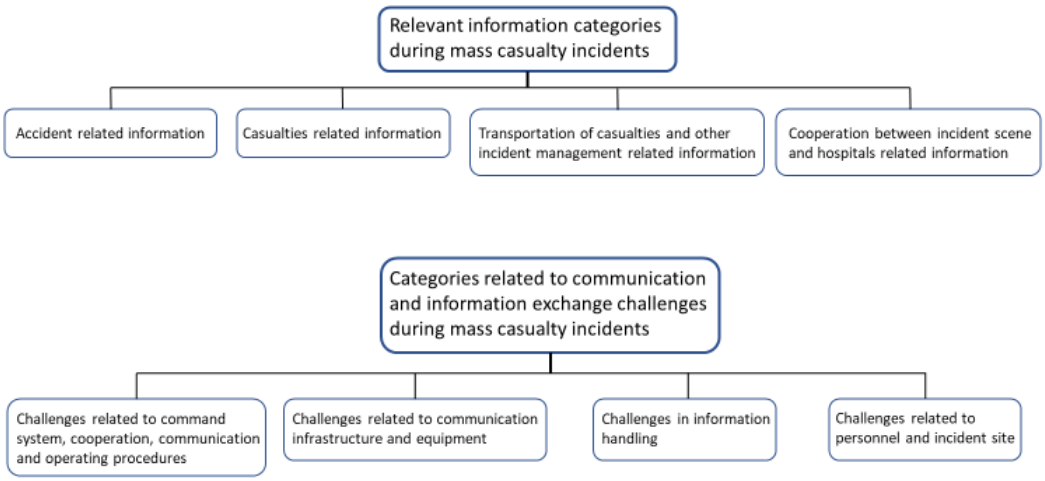

Figure 5: Categorization of emerged themes relating to relevant information and communication and information exchange related challenges during mass casualty incidents

5.1 The relevant information that is exchanged or transferred between incident sites and target hospitals

Accident related information

Accident related information was addressed in four studies. In the study by Holgersson (2016, 100) the relevant required early accident-related information was found to include aspects like the exact location of the incident, type of the incident and present and potential hazards relating to the incident. Lee et al. (2019, 63) point out in their study the need to inform about the number of vehicles involved in the incident. Norri-Sederholm et al. (2014, 155) address in their study the information need of paramedic field supervisor and found the relevant early accident related information to include external facts of the incident like mission code and safety related issues. Yang et al. (2012, 769-770) describe as essential on site information for the first responders to include environmental conditions.

Casualties related information

Casualties related information was addressed in nine studies. The need to define the number of patients inflicted by the incident was pointed out in four studies (Caglayan & Satoglu 2021, 320; Holgersson 2016, 100-101; Lee et al. 2019, 63; Madanian & Parry 2021, 2636-2637). The need to inform the severity of injuries or triage category of patients was presented by

Holgersson (2016, 100-101), Norri-Sederholm et al. (2014, 155), Tian et al. (2014, 8) and Yang et al. (2012, 769-770). The need to provide patient monitoring related information like vital signs and main complaints of the casualties was presented by Caglayan and Satoglu (2021, 320), Marres et al. (2013, 451), Tavakoli et al. (2017, 4) and Tian et al. (2014, 5) The need to provide demographic characteristics of patients like gender and age group definition or identification of casualties was presented by Tavakoli et al. (2017, 2-3) and Tian et al. (2014, 5). The need to provide patient medical information like blood type of patients and treatment information of inbound patients beforehand to allow hospitals to begin preparations and deploying their standard operating procedures is presented by Holgersson (2016, 100-101), Madanian and Parry (2021, 2624), Tavakoli et al. (2017, 2-3) and Tian et al. (2014, 4).

Transportation of casualties and other incident management related information

Transportation of casualties and other incident management related information was addressed in seven studies. Transportation of casualties related information includes aspects like the availability of ambulances and other resources, access routes for EMS units in incident site, transport time and destination hospital, transportation prioritization, providing transportation information of patients and defining of optimal vehicle movement routes to local hospitals (Caglayan & Satoglu 2021, 317; Holgersson 2016, 100; Lee et al. 2019, 63; Tavakoli et al. 2017, 2-3; Tian et al. 2014, 5; Yang et al. 2012, 769-770). Incident management related information includes resource management and on-site cooperation related information and defining extra resources required (Holgersson 2016, 100-101; Norri-Sederholm et al. 2014, 155).

Cooperation between incident scene and target hospitals related information

Cooperation between incident scene and hospitals related information was addressed in six studies. The need to define and share information on capacities of local hospitals was pointed out by Caglayan and Satoglu (2021, 317), Holgersson (2016, 101), Madanian and Parry (2021, 2636-2637) and Tian et al. (2014, 4). The need for preliminary alerting of the target hospital and informing or declaring “Major incident” within the target hospital was pointed out by Holgersson (2016, 100), Madanian and Parry (2021, 2624) and Norri-Sederholm et al. (2014, 155). The need for informing target hospitals about required capacity and specialist skills was presented by Holgersson (2016, 100-101), Madanian and Parry (2021, 2636-2637), Marres et al. (2013, 451) and Tian et al. (2014, 4).

The categorization of relevant information that is exchanged or transferred between incident sites and target hospitals is presented in Figure 6. Overview of the representation of different information needs in the included articles is presented in Table 3.

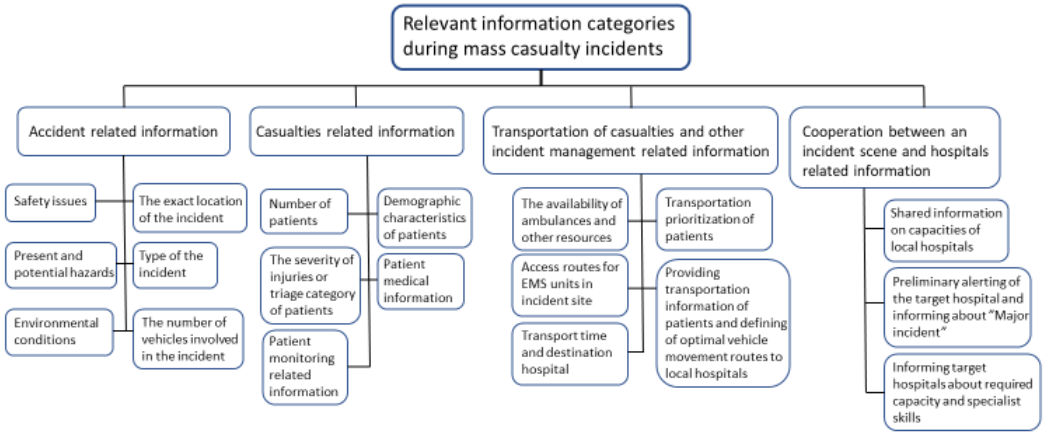

Figure 6: Recognized relevant information need categories during mass casualty incidents

Author (year)	Information need 1: Accident related information	Information need 2: Casualties related information	Information need 3: Transportation of casualties and other incident management related information	Information need 4: Cooperation between incident scene and hospitals related information
Allen et al. (2014)				
Caglayan & Satoglu (2021)		X	X	X
Holgersson (2016)	X	X	X	X
Lee et al. (2019)	X	X	X	
Madanian & Parry (2021)		X		X
Marres et al. (2013)		X		X
Norri-Sederholm et al. (2014)	X	X	X	X
Tavakoli et al. (2017)		X	X	
Tian et al. (2014)		X	X	X
Urquieta & Varon (2014)				
Yang et al. (2012)	X	X	X	

Table 3: Overview of the representation of different information needs in the included articles

5.2 Communication and information exchange related challenges in cooperation between authorities

Challenges related to command system, cooperation, communication and operating procedures

Challenges related to command system, cooperation, communication and operating procedures were addressed in eight studies. One of these challenges was defined to be the

need for pre-established communication and command system including set protocols and standards for cooperation and terminology (Allen et al. 2014, 426-427; Holgersson 2016, 95; Lee et al. 2019, 67; Marres et al. 2013, 446; Urquieta & Varon 2014, 311-312; Yang et al. 2012, 765). The poor integration of operating procedures was pointed out by Allen et al. (2014, 426-427) and Urquieta and Varon (2014, 312). The lack of cooperation and information related interplay on scene between different service providers and in general the lack of conceptual framework for information sharing was described by Allen et al. (2014, 420-423) and Yang et al. (2012, 765) to be problematic. In the study by Allen et al. (2014, 425) the flow of information was described to be vertical and hierarchical within individual organizations and information sharing focusing to the strategic apex. Command and control functions of different organizations might not be co-located thus resulting in fragmentation of shared object and hampering the maximum performance for all responders (Allen et al. 2014, 423; Yang et al. 2012, 765). The need for clear and secure method to document and transfer patient information through the chain of care was emphasized by Holgersson (2016, 99), Madanian and Parry (2021, 2635), Marres et al. (2013, 446) and Tian et al. (2014, 2). Allen et al. (2014, 420), Madanian and Parry (2021, 2624), Marres et al. (2013, 450) and Yang et al. (2012, 765) point out that pre-established operating systems and work practices need to be integrated into daily operating procedures to secure their usage also during an emergency response as first responders revert back to normal daily operating habits and routines during emergency response. Security, privacy and trust issues were emphasized by Allen et al. (2014, 419-427), Madanian and Parry (2021, 2628-2633), Marres et al. (2013, 447-452) and Yang et al. (2012, 765).

Challenges related to communication infrastructure and equipment

Challenges related to communication infrastructure and equipment were addressed in five studies. Allen et al. (2014, 419) describe allocation of used operating frequencies and transmission standards of individual first responder organizations to be problematic. Holgersson (2016, 99) defines equipment related technical deficiencies, inadequacies and malfunctions as communication challenge. Holgersson (2016, 99) also points out that incompatible communication systems and overload of the used equipment due to highly increased demand for use during major incident can hamper transmission of information. Madanian and Parry (2021, 2635-2637), Marres et al. (2013, 450-452) and Yang et al. (2012, 777-783) describe the vulnerability of the public information communication infrastructure to any kind of attacks or natural disasters and infrastructure degradation resulting possible physical damage to it and inflicting connections issues and delays in information exchange.

Challenges in information handling

Challenges in information handling were addressed in seven studies. Information overload was described as a challenge by Allen et al. (2014, 424) Norri-Sederholm et al. (2014, 157) and Yang et al. (2012, 781-782). Allen et al. (2014, 424) describes the information gathering in incident site as being focused to the relevant information for own organization´s processes and response. A lack of recognized methodology and conceptual framework for gathering, pooling and sharing of information was pointed out by Allen et al. (2014, 424), Urquieta and Varon (2014, 311-312) and Yang et al. (2012, 781-782). Madanian and Parry (2021, 2636) and Marres et al. (2013, 446-452) define disaster situation or mass casualty incident as chaotic possibly resulting misidentification of casualties. Security, privacy and trust issues were also emphasized as an information handling challenge by Allen et al. (2014, 419-427), Marres et al. (2013, 447-452), Tian et al. (2014, 2) and Yang et al. (2012, 765). Decision-making, multitasking and the need for constant communication related issues were pointed out by Norri-Sederholm et al. (2014, 152-157), Urquieta and Varon (2014, 312) and Yang et al. (2012, 765).

Challenges related to personnel and incident site

Challenges related to personnel and incident site were addressed in three studies. Holgersson (2016, 99) describes a lack of training, routine and inadequate compliance with organizational principles to possibly cause communication failures. Yang et al. (2012, 772-782) describes new technology related fear and insecurities of emergency personnel as one problem resulting deficient utilization of all the information available and thus reducing efficiency and accuracy of decision-making processes. Holgersson (2016, 99) points out that large incident sites were recognized to cause deficiencies in relaying information between first responders and also noise levels at the incident site can cause problems and delays in information exchange. Marres et al. (2013, 450) describe human errors due to unfamiliarity with the used equipment to possibly cause communication problems.

The categorization of communication and information exchange related challenges during mass casualty incidents is presented in Figure 7. Overview of the representation of communication and information exchange related challenge categories in the included articles is presented in Table 4.

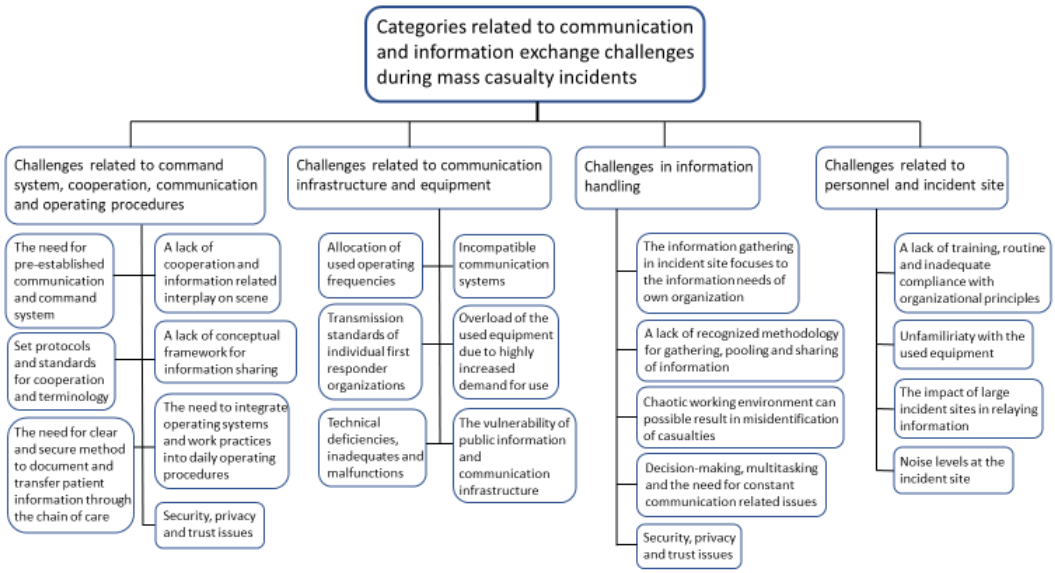

Figure 7: Recognized categories related to communication and information exchange challenges during mass casualty incidents

Author (year)	Challenge 1: Command system, cooperation, communication and operating procedures	Challenge 2: Communication infrastructure and equipment	Challenge 3: Information handling	Challenge 4: Personnel and incident site
Allen et al. (2014)	X	X	X	
Caglayan & Satoglu (2021)				
Holgersson (2016)	X	X		X
Lee et al. (2019)	X			
Madanian & Parry (2021)	X	X	X	
Marres et al. (2013)	X	X	X	X
Norri-Sederholm et al. (2014)			X	
Tavakoli et al. (2017)				
Tian et al. (2014)	X		X	
Urquieta & Varon (2014)	X		X	
Yang et al. (2012)	X	X	X	X

Table 4: Overview of the representation of communication and information exchange related challenge categories in the included articles

6 Discussion

The objective of this study was to explore the literature and to define information needs between incident sites and target hospitals and challenges related to communication and information exchange during mass casualty incidents. Communication and information exchange is generally recognized to be one of the most challenging and influential factors in emergency management. The findings of this study illustrate that there are still many

persistent challenges that require addressing and rigorous development. The results of this review can be used to assess and develop local, regional and national command and communication systems, cooperation, procedures, infrastructure and training in intraorganizational and interorganizational levels. The results of this study are discussed according to the research questions.

The effective creation of situational awareness due to a good information flow and the real-time information during mass casualty incident was emphasized in many of the included studies. It was presented that the target hospitals can utilize this real-time information provided to better prepare for individual patients and adjust their level of preparedness and capacity planning during the incident management. (Caglayan & Satoglu 2021, 320; Madanian & Parry 2021, 2624; Marres et al. 2013, 451.) Injuries of patients involved in a mass casualty incident can be versatile and require specialist skills. The preparations in the target hospitals require time as the emergency operations plan includes many tasks to complete. These tasks include aspects like gathering critical information to create situation picture and to define incident objectives, alerting additional personnel and required resources, implementing incident management strategy and related organizational changes, assigning roles, relocating patients and freeing resources. The amount of required preparations described here highlight the need for preliminary alerting of the target hospital to begin these preparations and to enable effective response and incident management in the target hospitals.

The information related to patients involved in the incident and the severity of their injuries guides the target hospitals in their preparations as they can better plan and adjust the assets and required skills and resources for individual patients. Demographic characteristics can also be important information referring the need for pediatrics or gynecologists. Transportation of patients related real-time information can be crucial as it enhances the use of limited resources in the hospital and especially the use of bottle-neck factors of surge capacity like imaging services by improving the timing and prioritization of processes.

The importance of integrating operating systems and work practices used during mass casualty incident into daily operating procedures was described to secure their smooth and effective usage also during an emergency response (Allen et al. 2014, 420). Efficient communication and information exchange during mass casualty incident was depicted to bolster utilization of limited resources and generally enhancing management of the incident and decision-making processes (Caglayan & Satoglu 2021, 317).

One important aspect to consider in mass casualty incident management is the surge capacity of all involved stakeholders. Caglayan and Satoglu (2021, 334) point out that especially in the beginning of severe disasters hospital capacities might be exceeded quickly. With the

situational awareness of capacities of local hospitals patients can be optimally distributed to local hospitals avoiding unnecessary stressing of capacities (Holgersson (2016, 101).

Holgersson (2016, 99), Marres et al. (2013, 446) and Tian et al. (2014, 2) identify the importance of clear and secure method to document and transfer correct and complete patient information through the chain of care to improve quality of care and patient outcome and to reduce change for possible human errors. The influence of visual presentation of information to creation of situational awareness, management processes and decision-making is recognized by Yang et al. (2012, 781-782).

A lack of cooperation in all interorganizational aspects and levels and the fragmentation of response was highlighted in the results of this review. The results of the review depict this clearly throughout the emergency management cycle and especially in the preparedness and response phases of it. It seems that strategic risk assessments and developed emergency operations plans has traditionally focused more to assessing and planning for external risks or alternatively to intraorganizational challenges but the interorganizational cohesive planning is still insufficient. The results illustrate that organizational or regional modifications to operational plans and command and communication systems are insufficient and ineffective means to address current challenges. These results describe the need for national or even international unified operational standards. Many of these aspects are described and emphasized in frameworks, standards and reports mentioned earlier in this study yet changes in larger scale seems prolonged. This challenge was addressed in 2021 in Finland with the unified guide assembled by Finnish Ministry of Social Affairs and Health and all five University Hospital Specific Catchment Areas in Finland. In this unified guide the national preparedness related communication and information systems are described and the operating models for management and utilization of these systems are represented. The three national communication and information systems included to the guide are the public safety network Virve, the mutual field operations system for authorities KEJO and emergency response centre data system ERICA. (Sosiaali- ja terveysministeriö 2021.)

Another aspect is the need to increase and strengthen the cooperation of first responder organizations in all levels including planning and training of response and incident management including aspects of communication and information exchange.

The results of the review depict that some progress has been made in strategic level and locally communication and information exchange can work to some extent in the strategic level. In tactical and operational levels interorganizational information interplay is pointed out to be lacking and even further the understanding of other organizations´ work and interplay with technology and information is described inadequate. The diversity and interoperability of existing communication and information systems is described problematic

as it inflicts data interoperability and hampers effective response. Another interorganizational challenge is trust issues and uncertainty relating to suitability and usefulness of information to other first responders that also arise from lacking knowledge and cooperation and insecurities relating to those. The used communication and information systems during emergency response are required to be reliable, secure, sufficiently flexible and interoperable for all relevant stakeholders. This is described challenging as the public information communication infrastructure is recognized to be vulnerable requiring contingency plans if utilized in emergency response.

In the study by Hugelius, Becker and Adolfsson (2020, 3075-3076) communication was recognized to be a common problem hindering establishment of a functional response organization. In their study communication failures were identified to be inflicted by technical issues, information management related deficiencies, a lack of information interplay between first responder organizations and language and terminology related issues. Hugelius et al. (2020, 3073-3076) point out there simply was a lack of means of communication. They also highlight the need for backup information and communication systems and adequate procedures and training to ensure sufficient emergency response. Findings of this integrative literature review are aligned with the findings of the study by Hugelius et al. (2020).

Most of discussed information needs and communication and information exchange related deficiencies during mass casualty incidents were addressed in general level in the included studies. The interplay of information, communication and cooperation between the incident site and the target hospitals were specifically addressed or mentioned to some extent in all but two included studies (Allen et al. 2014, Yang et al. 2012). This is an aspect that requires further research as an emergency response and planning and training of it still focuses mostly to the response efforts and organizations on the incident site and risks leaving hospitals out of the loop. This is contradictory as the main objective of the emergency response is to reduce impacts of the incident and save as many lives as possible and cooperation between EMS and hospitals is crucial in that context. Managing and handling of information is another aspect that calls for additional analysis in the future as the information sources and methods to compile it keep increasing setting challenges to filtering and pooling the relevant information and displaying it in an optimal way.

The results of this review are easily applicable to other contexts relating to mass casualty incident management. As described also in the results information needs of different organizations vary but almost all presented issues are shared by all organizations and their personnel involved in the incident management. Hospitals make a difference in information exchange as they provide relevant information to the managers in the incident site from outside the incident scene.

Inductive content analysis was used in this study for analysis of the results. Findings of the included studies were described, composed to coding sheets, categorized and generalized descriptions for all topics were formulated. Thematic analysis could have also been used for analysis of this study to some extent but some of the included studies were mixed method studies and observational studies so thematic analysis was not applicable approach for all the content.

6.1 Limitations

Most of the gathered communication related information in this study is general level information. There was a lack of information specifically on communication between the incident site and target hospitals. Due to this lack of information a comprehensive synthesis for gathered lessons and experiences in included studies must be used to provide evidence. The used systematic literature search methodology creation was challenging due to the broad subject and the need to limit ´hits´. Two of the included articles received low values (Tavakoli et al. 2017, Urquieta & Varon 2014) in the quality assessment reducing trustworthiness of the study. The inclusion of studies with different methodologies can possibly result on bias.

This was the first conducted ILR for the author and due to the lack of experience guidance was required throughout the thesis process. This inexperience hindered the ability of the author to evaluate the included studies and especially the methodological aspects and quality of those. This inexperience was addressed in my study with utilization of appropriate critical appraisal tools. The authors knowledge and expertise on the subject also alleviated some of these insecurities and supported the evaluation process of the results. Some findings in the included studies required interpretation possibly altering the intended message slightly.

The results of this study depict the global differences in development and current state of incident management systems. It must be emphasized that individual incident management systems including command and communication systems must be implemented with reference to the local context. The development phase of overall national incident management system and available resources need to be considered.

6.2 Ethical and legal considerations

In my thesis there are no conflicts of interest. All the data acquired and related to my thesis topic is open data. I do not handle personal information in my thesis. This thesis process has not received any funding and it does not have any significant linkages. I am aware that my thesis is a public document and will be checked with plagiarism identification system as part of the approval process.

7 Conclusion

This integrative literature review was conducted to investigate and clarify what information needs and aspects of communication and information exchange related deficiencies and challenges can be identified during mass casualty incidents. This review included eleven studies that were conducted with various designs. The main findings related to the information needs were preliminary alerting of the target hospitals to enable comprehensive preparations and providing real-time patient specific information to alleviate preparations for individual patients and the use of limited resources in the hospital. The biggest challenges related to the communication and information exchange were identified to be fragmentation of used command and information systems resulting to incoherent response and the need for national guidance to define and ensure unified operating systems and procedures for all first responders involved in mass casualty incidents. It was recognized that further research is required targeting specifically operational aspects and possibilities to enhance cooperation, communication and information exchange between the first responders in the incident sites and the target hospitals.

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Figures

Tables

Appendices

Appendix 1: Summary table of included studies

Reference	Author Year Country	Aims Setting	Study design Data Collection	Analysis Potential bias and limitations	Findings of the study	Rating of evidence
[1]	Allen et al. 2014 United Kingdom	The study focuses on emergency services and illustrates the key technological and organisational issues they face concerning information sharing and interoperability within an initial response phase. The defined research questions of the study were 1) How do emergency responders communicate and share information in order to achieve a shared objective? 2) How do organisational rules and norms influence information sharing and interoperability?	Observational study. The study is based on two studies that has focused on emergency services, IS and information management. In the first study researchers used a stratified purposeful sampling technique interviews. In the second study key informants in the EMS guided the sample strategy and the ´snow-ball´ technique followed that. Researchers conducted 12 extended interviews. Along with interviews organizational scanning and collecting supporting documentation was conducted to maintain a critical perspective.	Data analysis was conducted by using activity theory as the conceptual framework to answer the research questions. In the first study the focus of the analysis was on the work activities of the individual organizations. In the second study the focus of the analysis was on the interoperability and information sharing between managers of individual organizations. Methods limiting the potential for bias like conducting data collection from several sources was addressed.	Interoperability and information sharing problems: • Security, privacy and trust issues • Language and terminology related problems • Diversity of command systems and structures • Allocation of used operating frequencies and transmission standards of individual first responder organizations • Dependency on out-dated information and operating systems • Lack of consideration of implications to cross-organizational interoperability in planning • Information overload • Varying organizational priorities and informational needs • A fragmentation of response The lack of recognized methodology for gathering, pooling and sharing of information A lack of understanding other organizations´ work and interplay with technology and information During emergency response first responders revert back to normal daily operating habits and routines. Pre-established operating systems and work practices need to be integrated into daily operating procedures to secure their usage also during an emergency response The information gathering in incident site is focused to the relevant information for own organization´s processes and response A lack of information related interplay on-scene between different service providers Command and control functions of different organizations might not be co-located hindering further information sharing Even if used operating systems are similar information sharing can remain problematic due to poor integration of operating procedures and timing on utilization of used operating systems The impact of information overload to commanders in the initial phases of an incident	80%

					The flow of information is described vertical and hierarchical within individual organizations and information sharing focusing to the strategic apex The used language and terminology and uncertainty relating to suitability and usefulness of information to other first responders The tendency to engage the emergency situation in reflexive behaviour rather than in reflective behaviour. During initial phases of emergency situation decision makers tend to fill current information gaps using their previous experiences making assumptions	
[2]	Caglayan, N. & Satoglu, S.I. 2021 Turkey	The aim of the study was to streamline the disaster response and to minimize the number of casualties that will not be transported to the hospitals, the number of required additional ambulances and the transportation time of casualties. Research group assumed that a data-driven decision support tool would be employed to track casualties and real-time hospital capacities and utilized to direct the ambulances to the available hospitals. Researchers developed a multi-objective two-stage stochastic programming model that was applied to a scenario of major earthquake in Kartal district in Istanbul.	Quasi-experimental case-control study. The study integrates the used information system and the casualty transportation process. The study presents a decision support tool for casualty tracking and system monitoring and with the support of developed mathematical model maximum transportation service is provided for the casualties of the disaster. The existing hospitals and their capacities, EMS resources, the health scores of casualties and population of the region were taken into consideration in nine different scenarios with scenario-based parameters.	The augmented ε-constraint (AUGMECON2) method was used to solve the developed multi-objective stochastic programming model and then compared with the Pareto optimal solutions and assessed in relation to effectiveness and equity. In the study ambulances are assumed to be identical and to be able to transport only one casualty at the time	Decisions made need to be based on information regarding the availability of ambulances, capacities of local hospitals, the number and accessibility to the incident sites and the current traffic on the routes to hospitals Important real-time information gathered regarding management of the incident and affecting decisions made as the casualty number, their RPM scores (Respiratory rate, Pulse rate and Motor response values), hospitals' available capacities and ambulance dispatching	88%
[3]	Holgersson, A. 2016 Sweden	The aim of the IRL was to address mass casualty attack (MCA) response related challenges and to make improvement suggestions giving special attention to	Systematic review. Used databases included PubMed and Scopus. References from extracted articles were also screened.	The quality assessment of included articles was conducted by using an adapted model of evidence hierarchy that was based on descriptions of study design and evidence ratings.	Considering the capability and the current capacity and bed availability of local hospitals was also emphasized Making estimates of the number of casualties, their severity of injuries and the need for specialist skills Communicating to EMS central command and informing about 1) the exact location of the incident; 2) type of the incident; 3) present and potential hazards; 4) access routes for EMS	73%

		attacks on public transportation. The mass casualty scene involves a hazardous space, a crime scene and casualties needing medical treatment.	Database searches were conducted between July 2014 - May 2015. Articles published between 1970 and 2015 in the English language were included. Articles found in database searches were screened first by title, then abstracts and lastly the full texts were examined to determine articles that met the inclusion criteria or the exclusion criteria.	The quality of the included articles varied as the studied issue was hard to predict and control resulting to used inclusion criteria and exclusion criteria possibly effecting eligibility. Researchers recognize that broadness of the review and inclusion of articles of lower quality can set limitations for practical utilization of results.	units and the location of the Incident Command Point; 5) the estimated number of casualties and severity of their injuries; and 6) extra resources required. The need to inform or declare "Major incident" was highlighted Communication challenges were defined to include equipment related technical deficiencies, inadequacies and malfunctions, information exchange related problems and diversity of used protocols like used triage systems and terminology. Equipment related technical issues are usually caused by incompatible communication systems, overload of the used equipment due to highly increased demand for use or physical damage to the used communication infrastructure. These challenges caused problems with transmission of information between first responders within the incident site, along the chain of command and to other authorities including hospitals Communication failure related causes are defined to include also information exchange process related findings like lack of training, routine and inadequate compliance with organizational principles. Large incident sites were recognized to cause deficiencies in relaying information between first responders. Noise levels at the incident site can cause problems and delays in information exchange Information exchange about the patients and the coordination of triage, treatment and transfer of patients was recognized as a challenge between the incident site and hospitals. Holgersson points out the general recommendation and need for clear and secure method to document and transfer patient information through the chain of care The need to standardize the command structures, to create clear jurisdictions and roles defining tasks and responsibilities and to unify the used language and terminology	
[4]	Lee et al. 2019 Republic of Korea	The purpose of the study was to analyze accident management system by using several investigation methods like analyzing medical records and interviewing the injured patients, visiting car-repair shops and investigating damaged vehicles. The study was conducted by using retrospective approach to analyze 43-vehicle mass collision on expressway.	A retrospective case study / Observational study. The study included interviews of injured patients, investigation of damaged vehicles, reproduction of the accident scene and assessment of medical records using the Injury Severity Score (ISS). Patient information was collected form National Emergency Medical Center (NEMC) and individual injured patients, 119	The accident scene was reproduced and analyzed with the accident situation sketch program Easy Street Draw 6. The whole medical records of patients´ were analyzed, coded and rechecked. Patients involved in the accident were interviewed about health and safety issues. The severity of patients´ injuries were presented with AIS and ISS scales. The cause of the accident and occurrence of most severely injured occupants were identified. The incident management system related aspects were analyzed.	Number of patients and vehicles involved in the accident, providing transportation information of patients to hospitals and definition of optimal vehicle movement routes Need for pre-established communication and command system and protocols and set standards for cooperation	86%

			paramedics and trainee drivers were interviewed. Vehicles involved in the accident were photographed and vehicle specific safety information was gathered.	Researchers state as the limitation of the study that they were not able to complete the investigation on all involved vehicles and injured patients.		
[5]	Madanian, S. & Parry, D. 2021 New Zealand	The objective of the study was to identify the role of RFID technology in healthcare activities in all phases of emergency cycle and possible application areas. The study examines utilization of technologies to support decision-making processes of healthcare and emergency managers during disaster situations.	Qualitative study. Study was conducted by using a Delphi approach. Two rounds of questionnaires including open- and closed-ended questions were conducted to nine experts to examine and evaluate RFID applications for healthcare field. The participants were experts of information systems, disaster management and disaster medicine.	First data analysis was conducted after the first questionnaire and feedback provided by experts and the results of the analysis were utilized in the preparation of second questionnaire. Researchers analyzed and measured after both questionnaires the feedback provided by experts and their level of agreement by utilizing qualitative and subjective analysis. The consensus was measured with frequency distribution. No potential bias or limitations addressed.	Real-time information can be casualty related medical information like blood type that emergency managers in local hospitals can use to begin preparations like transferring patients, allocating resources and deploying their standard operation procedures (SOP) The need for information regarding number of inbound casualties, the number of available hospital beds and other medical resources and Electronic Health Record (EHR) The importance of implementing and integrating technological applications used in disaster management also to daily operations or alternatively the human interaction of such technology must be minimized and automation of the system maximized Security and privacy of data as the biggest challenge for RFID technologies and communication in general due to infrastructure degradation Network infrastructure can be damaged and interrupted during disasters and temporary data capturing, storing and delayed uploading of this data after connectivity is re-established can be problematic As problems relating to triage Madanian et al. point out over-triage and possibility of losing paper triage. Casualty identification related problems Chaotic disaster situations and misidentification of casualties	90%
[6]	Marres, G. et al. 2013 The Netherlands	It is pointed out in the study that casualty related information is often lacking during major incidents. The study describes the development of an online Victim Tracing and Tracking System (ViTTS) that can be utilized to record and exchange casualty related information.	Mixed method study. The feasibility and usability of ViTTS was tested in multidisciplinary major incident scenario in Netherlands in 2005. The test scenario involved forty victims, a mobile medical team, three ambulances and other first responder organizations´ personnel and hospital personnel in the Major	Independent qualified Dutch research institute TNO-ICT evaluated the feasibility and usability of ViTTS. The focus of the TNO-ICT evaluation was on functionality and reliability of the system, storing and availability of data and usability of system related equipment. The most significant limitation of the exercise was the relatively low number of victims.	The target hospitals can utilize this real-time information provided by ViTTS to better prepare for individual patients and adjust their level of preparedness and capacity planning during the incident management Correct and complete information about casualties is recognized in the study by Marres et al. (2013) to be one of the biggest challenges for coordinated and efficient medical response Data interoperability is defined as a worldwide problem during mass casualty incidents that hampers communication and information sharing and ultimately effective medical response including triage, patient allocation and transport to target hospitals and hospital preparations The lack of or ineffective integration of different systems of first responders Cybersecurity and data ownership issues are addressed with agency specific requirements and authorization and integrated authentication mechanism to verify patient privacy	79%

			Incident Hospital (MIH) in Utrecht.		Human errors due to unfamiliarity with PDAs and ViTTS system and incomplete automatic functions in scanning and switching back to primary network were identified as deficiencies of ViTTS system Used platforms like ViTTS should be in daily use and not just during mass casualty incidents, the systems require flexibility and secure data exchange, data needs to be clinically-based and the system should automatically generate identification number for each incident The connection issues and system integrity could be further secured with an extra satellite gateway and in-hospital data integration should be further ensured by training of hospital personnel	
[7]	Norri-Sederholm, T. et al. 2014 Finland	The study aims to describe and analyze relevant information for paramedic field supervisor for creation of situational awareness in prehospital emergency care.	Qualitative study. Ten paramedic field supervisors participated to the study form different parts of Finland. Data collection was conducted with semistructured interviews between January 2012 – March 2012. Researchers audio-recorded interviews. Three realistic scenarios were used to identify the varying information needs of paramedic field supervisors in these different scenarios.	Deductive content analysis was used to analyze the results. Interview data was first categorized with the information exchange meta-model, transcripted verbatim and then coded into 20 information categories by using Atlas.ti 7. Validity of coding was ensured by checking every code individually. The main limitation in this study was that it was impossible to generate and collect data from real-life situations without the risk of affecting the quality of the paramedic field supervisors' daily work. One question that should have been asked was whether the sample, ten paramedic field supervisors, was sufficient and representative. The study was conducted in one country: Finland. From a research point of view, the intention was not to generalize the results; rather, it was more to test the model to determine its suitability in prehospital emergency care.	Paramedic field supervisors information need was the highest regarding external facts of the incident including event-related information from other first responders like mission code, safety issues and triage. Out of internal facts paramedic field supervisors regarded as most important information needs to be information sharing, giving instructions and orders, ensuring safety, preliminary alerting of the target hospital, resource management and cooperation with other first responders. Paramedic field supervisors have four different roles as they act as situation followers, analyzers, planners and decision makers. Paramedic field supervisors need to make quick decisions while receiving constant information and sharing information with other stakeholders	95%
[8]	Tavakoli, N. et al. 2017	The study aims to develop a patient tracking system for	Two-step applied qualitative study.	Content analysis was used to analyze data gathered about	The minimum data set of patients to contain demographic characteristics, appearance specifications, medical information and location information. This gathered patient related	60%

	Iran	disaster management in Iran. Previously there were no processes or systems to manage the information of disaster casualties in Iran.	Development process included data collection of disaster patient tracking systems used in other countries and modelling of a preliminary disaster patient tracking system for Iranian context by using Delphi technique and focus group. Data collection of patient tracking systems was conducted by using a data extraction form. Twenty participants in the first and second round and sixteen participants in the third round of delphi technique included experts of health information systems and management, administrative personnel, medical personnel and emergency management specialists.	patient tracking systems used in other countries. Descriptive statistics was used to analyze the data gathered in the three Delphi rounds. No potential bias or limitations addressed.	information needs to be exchanged and updated regularly with relevant stakeholders like responsive hospital´s emergency departments. The gathered information by the first responders in the scene is described to include identification or photographing of the patients for later identification, monitoring and registering vital signs and the main complaints of the patients, given treatment and scene management related information.	
[9]	Tian, Y. et al. 2014 China	The study presents a mobile-based system for emergency triage supporting transportation prioritization of patients during mass casualty incidents (MCI). Emergency management is described as a multiorganizational response process that requires different information systems to support management of the patient´s emergency data and the operations in the incident site.	Mixed method study. To test the feasibility of the presented information system the emergency data of patients admitted to the ED at the Second Affiliated Hospital of Zhejiang University School of Medicine between January 2013 – November 2013 were included. All patients with the disease type trauma were included.	The survival analysis was conducted for the included patients with Cox regression and curve fitting using set variables for the condition of patients and age categories. Researchers recognize the challenges in applying the results of the study to operational emergency response processes.	Injury information and current health status of the casualties needs to be gathered and shared with all the relevant stakeholders and the transportation prioritization decided. Relevant casualty information for their system prior to arriving to receiving hospital to include patient demographic information, patient vital signs, patient triage and treatment information and patient transportation information. Patient demographic information entails unique patient identifier, patient´s gender and age group definition. Patient vital signs include systolic blood pressure, respiratory rate, pulse, Glascow Coma Scale, oxygen saturation and body temperature. Patient triage and treatment information includes injury time, area, and type, START triage level and treatment information. Patient transportation information includes transport time and destination hospital, used vehicle for transportation, transport priority and transport body position for patient. The emergency response capacity and capabilities of the local hospitals are seen as a notable information impacting on decision-making of triage officer in forming optimal transportation plan for the casualties. Tian et al. describe as important information for the doctors in the hospital to include injury information of casualties and all given treatment information.	74%

					Challenges related to an MCI are identified as assessing the scale of the MCI and integrating and allocating the available medical resources efficiently. Tian et al. describe paper documents as easy to use but they remark about related deficiencies of those like accuracy and inadequacy of information transmission and problems related to the utilization of information. The START triage and other traditional triage schemas having too static and overlapping categories resulting in poor adaptability for diversity of different incident types and resulting in considerable over-triage and possible misled prioritization of casualties.	
[10]	Urquieta, E. & Varon, J. 2014 USA	The objective of the study is to describe the experiences and conclusions made from an explosion accident in a government building in Mexico City in January 2013 and to present the current risk assessment for mass casualty disasters and disaster management strategies in Mexico City. Case study of the explosion accident in the third tallest building in the Mexico City in 2013.	Observational case-control study. This study describes the sequence of events, case related recognized challenges and lessons and future recommendations.	Analysis process not described. No potential bias or limitations mentioned.	A lack of set protocols, procedures and terminology for information exchange Communication protocols during disasters should include usage of common medical language and avoiding codes to prevent misinformation and misunderstandings The need for constant and clear communication and coordination among all first responders including intrahospital and interhospital communication	64%
[11]	Yang, L. et al. 2012 United Kingdom	The project aimed to develop an integrated information platform for emergency response operations in the 2008 Beijing Olympics. The study examines the challenges related to designing an integrated information platform and user-specific considerations provided by emergency personnel.	A qualitative case study. The prototype of an integrated information platform was repeatedly evaluated and enhanced through the development process with the help of end-user feedback. The organizations for participatory design were chosen according to sufficient responsibilities relating to safety, participation directly to emergency response operations or based on	The data gathered in interviews was compiled and presented in the three workshops to assess, refine and confirm the findings. No potential bias or limitations addressed.	Essential on-site information for first responders to include environmental conditions, information related to the first responders on the scene, the status of the casualties and the available resources Information related problem during an emergency response to include defining the relevant information for different stakeholders, organizing that information to avoid overload and duplication of information and optimal presentation of the information to enable maximum performance for all responders. New technology related fear and insecurities of emergency personnel is emphasized by Yang et al. as one problem resulting deficient utilization of all the information available and thus reducing efficiency and accuracy of decision-making processes Emergency management systems infrequent use in practice and overall utilization only in emergency situations is seen problematic.	90%

			direct authority over the organizations that met one of the first two criterias. Field studies that included making observations, interviews, workshops and round-table discussions were conducted with emergency personnel to elucidate information needs, service requirements and to manage the system evaluation. Over 100 emergency personnel participated to the interviews. Interviews were recorded with a digital recorder and transcribed.		The fragmentation of existing information systems and differentiating needs for information is also described problematic as dynamic information for all responders is described critical for emergency response. Yang et al. point out the difference between working on-site during an emergency response and normal daily operations as the level of cooperation and interaction with other organizations during an emergency response is much more profound. This is generally seen as a lack of trust and understanding between different first responder organizations. Yang et al. point out the security risks regarding public communication media-based decision support systems and the general need for reliability and flexibility of decision support systems. The public information communication infrastructure is described being vulnerable to interruptions caused by any kind of attacks or natural disasters.	

Appendix 2: Quality assessment of qualitative studies (CASP)

References	1	2	3	4	5	6	7	8	9	10	Score	%
Madanian & Parry. 2021	√√	√√	√√	√√	√√	√	√	√√	√√	√√	18/20	90%
Norri-Sederholm et al. 2014	√√	√√	√√	√√	√√	√√	√	√√	√√	√√	19/20	95%
Tavakoli et al. 2017	√√	√√	√	√	√	√	0	√	√√	√	12/20	60%
Yang et al. 2012	√√	√√	√√	√√	√√	√	√	√√	√√	√√	18/20	90%

1. Clear aims of the research are stated.
2. Appropriate qualitative methodology is used.
3. Research design is appropriate to address the research aims.
4. Appropriate recruitment strategy to the research aims is presented.
5. Research issue is addressed by the proper data collection method.
6. Adequate consideration of relationship between participants and researcher is established.
7. Adequate consideration of ethical issues is presented.
8. Sufficiently rigorous data analysis is presented.
9. Findings of the study are stated clearly.
10. The value of the research is defined and discussed.

√√ Satisfies assessment criteria

√ Partly satisfies assessment criteria

0 Does not satisfy assessment criteria

X Assessment criteria do not apply

Appendix 3: Quality assessment of observational studies (STROBE statement)

References	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Score	%
Allen et al. 2014	√√	√√	√√	√√	√	√√	√	√√	√	√	X	X	√√	√	√√	√√	√√	√√	√	√√	√	√	32/40	80%
Caglayan & Satoglu 2021	√√	√√	√√	√√	√√	√√	√√	√√	0	√√	√√	√√	√√	X	√√	√√	√√	√√	0	√√	√	√√	37/42	88%
Lee et al. 2019	√√	√√	√√	√√	√√	√√	√√	√√	0	√√	√√	√√	√√	√√	√√	√√	√√	√√	√	√√	√	0	38/44	86%
Urquieta & Varon. 2014	√√	√√	√	0	√	√√	√√	0	0	√√	√√	√√	√√	√√	√√	√√	√	√√	0	√	0	0	28/44	64%

1. Title and abstract of the study are clear.
2. Scientific background and rationale of the study is explained.
3. Specific objectives of the study are stated.
4. Study design is clearly presented early in the paper.
5. Setting, locations and relevant dates of the study are described.
6. Eligibility criteria of participants are presented.
7. Variables are defined clearly.
8. Data sources and methods of data measurement are explained.
9. Potential sources of bias are addressed.
10. Study size is explained.
11. Quantitative variables are explained.
12. Statistical methods are described.
13. Number of participants and other related information are presented.
14. Descriptive data is presented.
15. Outcome data is reported.
16. Main results are reported.
17. Other analyses are reported.
18. Key results are summarized with reference to study objectives.
19. Study limitations are discussed.
20. Overall interpretation of results is presented.
21. Generalisability of the study results is discussed.
22. Sources of funding and the role of the funders is presented.

√√ Satisfies assessment criteria

√ Partly satisfies assessment criteria

0 Does not satisfy assessment criteria

X Assessment criteria do not apply

Appendix 4: Quality assessment of Systematic review (modified JBI Global checklist for systematic reviews and research synthesis)

References	1	2	3	4	5	6	7	8	9	10	11	Score	%
Holgersson 2016	√	√	√	√√	√	0	√√	√√	√√	√√	√√	16/22	73%

1. The review question(s) are clearly and explicitly stated
2. The inclusion criteria were appropriate for the review question
3. The selected search strategy was appropriate
4. The used sources and resources to search for studies were adequate
5. The criteria for appraising studies were appropriate
6. Critical appraisal was conducted by two or more reviewers independently
7. There were methods to minimize errors in data extraction
8. The methods used to combine studies and form a synthesis were appropriate
9. The limitations and potential sources of bias were assessed
10. Recommendations for policy and/or practice were supported by the reported data
11. The specific directives for new research were appropriate

√√ Satisfies assessment criteria

√ Partly satisfies assessment criteria

0 Does not satisfy assessment criteria

X Assessment criteria do not apply

Appendix 5: Quality assessment with diverse studies (QuADS)

References	1	2	3	4	5	6	7	8	9	10	11	12	13	Score	%
Marres et al. 2013	3	3	3	3	3	2	3	3	1	2	1	2	2	31/39	79%
Tian et al. 2014	3	3	3	2	2	3	2	3	1	3	3	0	1	29/39	74%

1. Theoretical or conceptual background to the research
2. Statement of research aim/s
3. Clear description of research setting and target population
4. The study design is appropriate to address the stated research aim/s
5. Appropriate sampling to address the research aim/s
6. Rationale for choice of data collection tool/s
7. The format and content of data collection tool is appropriate to address the stated research aim/s
8. Description of data collection procedure
9. Recruitment data provided
10. Justification for analytic method selected
11. The method of analysis was appropriate to answer the research aim/s
12. Evidence that the research stakeholders have been considered in research design or conduct
13. Strengths and limitations critically discussed

0 No mention at all / Criteria topic not addressed

1 General/limited reference or description of criteria topic is presented

2 Criteria topic is addressed but is lacking details, refinement or explicit discussion or more suitable alternative could have been used

3 Explicit and detailed description or discussion on criteria topic is presented and detailed justification for choice of analytic method and study design is provided

Appendix 6: Description of the data analysis processes

a) Recognized information needs between incident sites and target hospitals

Lee et al. 2019

- The number of patients and vehicles involved in the accident, providing transportation information of patients to hospitals and definition of optimal vehicle movement routes (Lee et al. 2019, 63).

Caglayan & Satoglu 2021

- Decisions made need to be based on information regarding the availability of ambulances, capacities of local hospitals, the number and accessibility to the incident sites and the current traffic on the routes to hospitals (Caglayan & Satoglu 2021, 317).
- Important real-time information gathered regarding management of the incident and affecting decisions made as the casualty number, their RPM scores (Respiratory rate, Pulse rate and Motor response values), hospitals' available capacities and ambulance dispatching (Caglayan & Satoglu 2021, 320).

Holgersson 2016

- Considering the capability and the current capacity and bed availability of local hospitals was also emphasized (Holgersson 2016, 101).
- Making estimates of the number of casualties, their severity of injuries and the need for specialist skills (Holgersson 2016, 100-101).
- Communicating to EMS central command and informing about 1) the exact location of the incident; 2) type of the incident; 3) present and potential hazards; 4) access routes for EMS units and the location of the Incident Command Point; 5) the estimated number of casualties and severity of their injuries; and 6) extra resources required. The need to inform or declare "Major incident" was highlighted. (Holgersson 2016, 100.)

Madanian & Parry 2021

- Real-time information can be casualty related medical information like blood type that emergency managers in local hospitals can use to begin preparations like

transferring patients, allocating resources and deploying their standard operation procedures (SOP) (Madanian & Parry 2021, 2624).

- The need for information regarding number of inbound casualties, the number of available hospital beds and other medical resources and Electronic Health Record (EHR) (Madanian & Parry 2021, 2636-2637).

Marres et al. 2013

- The target hospitals can utilize this real-time information provided by ViTTS to better prepare for individual patients and adjust their level of preparedness and capacity planning during the incident management (Marres et al. 2013, 451).

Norri-Sederholm et al. 2014

- Paramedic field supervisors information need was the highest regarding external facts of the incident including event-related information from other first responders like mission code, safety issues and triage (Norri-Sederholm et al. 2014, 155).
- Out of internal facts paramedic field supervisors regarded as most important information needs to be information sharing, giving instructions and orders, ensuring safety, preliminary alerting of the target hospital, resource management and cooperation with other first responders (Norri-Sederholm et al. 2014, 155).

Tavakoli et al. 2017

- The minimum data set of patients to contain demographic characteristics, appearance specifications, medical information and location information. This gathered patient related information needs to be exchanged and updated regularly with relevant stakeholders like responsive hospital´s emergency departments. (Tavakoli et al. 2017, 2-3.)
- The gathered information by the first responders in the scene is described to include identification or photographing of the patients for later identification, monitoring and registering vital signs and the main complaints of the patients, given treatment and scene management related information (Tavakoli et al. 2017, 4).

Tian et al. 2014

- Injury information and current health status of the casualties needs to be gathered and shared with all the relevant stakeholders and the transportation prioritization decided (Tian et al. 2014, 2).
- Relevant casualty information for their system prior to arriving to receiving hospital to include patient demographic information, patient vital signs, patient triage and treatment information and patient transportation information. Patient demographic information entails unique patient identifier, patient´s gender and age group definition. Patient vital signs include systolic blood pressure, respiratory rate, pulse, Glascow Coma Scale, oxygen saturation and body temperature. Patient triage and treatment information includes injury time, area, and type, START triage level and treatment information. Patient transportation information includes transport time and destination hospital, used vehicle for transportation, transport priority and transport body position for patient. (Tian et al. 2014, 3, 5, 8.)
- The emergency response capacity and capabilities of the local hospitals are seen as a notable information impacting on decision-making of triage officer in forming optimal transportation plan for the casualties (Tian et al. 2014, 4).
- Tian et al. describe as important information for the doctors in the hospital to include injury information of casualties and all given treatment information (Tian et al. 2014, 4).

Yang et al. 2012

- Essential on-site information for first responders to include environmental conditions, information related to the first responders on the scene, the status of the casualties and the available resources (Yang et al. 2012, 769-770).

Initial coding

1. The number of patients involved in the accident (Caglayan & Satoglu 2021, Holgersson 2016, Lee et al. 2019, Madanian & Parry 2021, Marres et al. 2013)
2. The number of vehicles involved in the accident (Lee et al. 2019)
3. Severity of injuries (Holgersson 2016); triage category of patients (Norri-Sederholm et al. 2014, Tian et al. 2014)
4. Casualty RPM scores (Respiratory rate, Pulse rate and Motor response values) (Caglayan & Satoglu 2021); monitoring and registering vital signs and the main

complaints of the patients (Tavakoli et al. 2017, Tian et al. 2014); the status of the casualties (Yang et al. 2012)

5. Demographic characteristics (patient´s gender and age group definition) (Tavakoli et al. 2017, Tian et al. 2014); identification of casualties (Tavakoli et al. 2017)
6. Medical information like blood type of casualties (Madanian & Parry 2021, Tavakoli et al. 2017)
7. Given treatment (Tavakoli et al. 2017); treatment information (Tian et al. 2014)
8. Transportation information of patients to hospitals and definition of optimal vehicle movement routes (Lee et al. 2019, Tian et al. 2014); accessibility to the incident sites and the current traffic on the routes to hospitals (Caglayan & Satoglu 2021); access routes for EMS units (Holgersson 2016); location information of patients (Tavakoli et al. 2017)
9. Scene management related information (Tavakoli et al. 2017); resource management and cooperation with other first responders (Norri-Sederholm et al. 2014); extra resources required (Holgersson 2016)
10. The availability of ambulances and other resources (Caglayan & Satoglu 2021, Yang et al. 2012)
11. Capacities of local hospitals (Caglayan & Satoglu 2021, Holgersson 2016; Madanian & Parry 2021, Marres et al. 2013, Tian et al. 2014)
12. The need for specialist skills (Holgersson 2016); other medical resources (Madanian & Parry 2021)
13. The exact location of the incident (Holgersson 2016)
14. Type of the incident (Holgersson 2016)
15. Present and potential hazards (Holgersson 2016); safety issues (Norri-Sederholm et al. 2014); environmental conditions (Yang et al. 2012)
16. Preliminary alerting of the target hospital (Norri-Sederholm et al.2014); the need to inform or declare “Major incident” (Holgersson 2016)

Enhanced coding

1. The exact location of the incident (Holgersson 2016); type of the incident (Holgersson 2016); present and potential hazards (Holgersson 2016); the number of vehicles involved in the accident (Lee et al. 2019); safety issues (Norri-Sederholm et al. 2014); environmental conditions (Yang et al. 2012)
2. The number of patients involved in the accident (Caglayan & Satoglu 2021, Holgersson 2016, Lee et al. 2019, Madanian & Parry 2021, Marres et al. 2013); severity of injuries (Holgersson 2016); triage category of patients (Norri-Sederholm et al. 2014, Tian et al. 2014); casualty RPM (Respiratory rate, Pulse rate and Motor response values)

scores (Caglayan & Satoglu 2021); monitoring and registering vital signs and the main complaints of the patients (Tavakoli et al. 2017, Tian et al. 2014); the status of the casualties (Yang et al. 2012); demographic characteristics (patient´s gender and age group definition) (Tavakoli et al. 2017, Tian et al. 2014); identification of casualties (Tavakoli et al. 2017); medical information like blood type of casualties (Madanian & Parry 2021, Tavakoli et al. 2017); given treatment (Tavakoli et al. 2017); treatment information (Tian et al. 2014)

3. Transportation information of patients to hospitals and definition of optimal vehicle movement routes (Lee et al. 2019, Tian et al. 2014); accessibility to the incident sites and the current traffic on the routes to hospitals (Caglayan & Satoglu 2021); access routes for EMS units (Holgersson 2016); location information of patients (Tavakoli et al. 2017); the availability of ambulances and other resources (Caglayan & Satoglu 2021, Yang et al. 2012); scene management related information (Tavakoli et al. 2017); resource management and cooperation with other first responders (Norri-Sederholm et al. 2014); access routes for EMS units (Holgersson 2016); extra resources required (Holgersson 2016)
4. Capacities of local hospitals (Caglayan & Satoglu 2021, Holgersson 2016; Madanian & Parry 2021, Marres et al. 2013, Tian et al. 2014); the need for specialist skills (Holgersson 2016); other medical resources (Madanian & Parry 2021); preliminary alerting of the target hospital (Norri-Sederholm et al. 2014); the need to inform or declare “Major incident” (Holgersson 2016)

Final coding

1. Accident related information (Holgersson 2016, Lee et al. 2019, Norri-Sederholm et al. 2014, Yang et al. 2012)
2. Casualties related information (Caglayan & Satoglu 2021, Holgersson 2016, Lee et al. 2019, Madanian & Parry 2021, Marres et al. 2013, Norri-Sederholm et al. 2014, Tavakoli et al. 2017, Tian et al. 2014, Yang et al. 2012)
3. Transportation of casualties and other incident management related information (Caglayan & Satoglu 2021, Holgersson 2016, Lee et al. 2019, Norri-Sederholm et al. 2014, Tavakoli et al. 2017, Tian et al. 2014, Yang et al. 2012)
4. Cooperation between incident scene and hospitals related information (Caglayan & Satoglu 2021, Holgersson 2016; Madanian & Parry 2021, Marres et al. 2013, Norri-Sederholm et al. 2014, Tian et al. 2014)

b) Recognized challenges in communication and information exchange

Lee et al. 2019

- The need for pre-established communication and command system and protocols and set standards for cooperation (Lee et al. 2019, 67).

Urquieta & Varon 2014

- A lack of set protocols, procedures and terminology for information exchange (Urquieta & Varon 2014, 311-312).
- Communication protocols during disasters should include usage of common medical language and avoiding codes to prevent misinformation and misunderstandings (Urquieta & Varon 2014, 312).
- The need for constant and clear communication and coordination among all first responders including intrahospital and interhospital communication (Urquieta & Varon 2014, 312).

Allen et al. 2014

- A complex and information intensive environment that requires increased interoperability with other stakeholders (Allen et al. 2014, 419).
- Presented lists of interoperability and information sharing problems (Allen et al. 2014, 419, 427-428).
    1. security and trust concerns
    2. language related problems with managing systems in multinational operations
    3. diversity of command structures and cultures
    4. allocation of used operating frequencies and transmission standards of individual first responder organizations
    5. dependence on legacy systems
    6. implementation of individual systems to organizations´managing systems without considering implications to cross-organizational interoperability
    1. use of different non-material tools creating interoperability problems with terminology and use of abbreviations
    2. managing information overload
    3. privacy and security related organizational issues
    4. different organizational priorities and environmental cues to act on
    5. a fragmented division of labour creating isolated ways of working

- The lack of conceptual frameworks for information sharing and interoperability (Allen et al. 2014, 420).
- A lack of recognized methodology for gathering and pooling of information (Allen et al. 2014, 424).
- A lack of understanding other organizations´ work and interplay with technology and information (Allen et al. 2014, 420).
- During emergency response first responders revert back to normal daily operating habits and routines. Pre-established operating systems and work practices need to be integrated into daily operating procedures to secure their usage also during an emergency response (Allen et al. 2014, 420).
- The information gathering in incident site is focused to the relevant information for own organization´s processes and response (Allen et al. 2014, 424).
- No information related interplay on-scene between different service providers (Allen et al. 2014, 423).
- Command and control functions of different organizations might not be co-located hindering further information sharing (Allen et al. 2014, 423).
- Even if used operating systems are similar information sharing can remain problematic due to poor integration of operating procedures and timing on utilization of used operating systems (Allen et al. 2014, 426-427).
- The impact of information overload to commanders in the initial phases of an incident (Allen et al. 2014, 424).
- The flow of information is described vertical and hierarchical within individual organizations and information sharing focusing to the strategic apex (Allen et al. 2014, 425).
- The used language and terminology and uncertainty relating to suitability and usefulness of information to other first responders (Allen et al. 2014, 426-427).
- The tendency to engage the emergency situation in reflexive behaviour rather than in reflective behaviour. During initial phases of emergency situation decision makers tend to fill current information gaps using their previous experiences making assumptions. (Allen et al. 2014, 428.)

Holgersson 2016

- Communication challenges were defined to include equipment related technical deficiencies, inadequacies and malfunctions, information exchange related problems and diversity of used protocols like used triage systems and terminology. Equipment related technical issues are usually caused by incompatible communication systems,

overload of the used equipment due to highly increased demand for use or physical damage to the used communication infrastructure. These challenges caused problems with transmission of information between first responders within the incident site, along the chain of command and to other authorities including hospitals. (Holgersson 2016, 94-95, 99, 101.)

- Communication failure related causes are defined to include also information exchange process related findings like lack of training, routine and inadequate compliance with organizational principles. Large incident sites were recognized to cause deficiencies in relaying information between first responders. Noise levels at the incident site can cause problems and delays in information exchange. (Holgersson 2016, 99.)
- Information exchange about the patients and the coordination of triage, treatment and transfer of patients was recognized as a challenge between the incident site and hospitals. Holgersson points out the general recommendation and need for clear and secure method to document and transfer patient information through the chain of care. (Holgersson 2016, 99.)
- The need to standardize the command structures, to create clear jurisdictions and roles defining tasks and responsibilities and to unify the used language and terminology (Holgersson 2016, 95).

Madanian & Parry 2021

- The importance of implementing and integrating technological applications used in disaster management also to daily operations or alternatively the human interaction of such technology must be minimized and automation of the system maximized (Madanian & Parry 2021, 2624).
- Security and privacy of data as the biggest challenge for RFID technologies and communication in general due to infrastructure degradation (Madanian & Parry 2021, 2628, 2633).
- Network infrastructure can be damaged and interrupted during disasters and temporary data capturing, storing and delayed uploading of this data after connectivity is re-established can be problematic (Madanian & Parry 2021, 2635, 2637).
- As problems relating to triage Madanian et al. point out over-triage and possibility of losing paper triage. Casualty identification related problems (Madanian & Parry 2021, 2635).
- Chaotic disaster situations and misidentification of casualties (Madanian & Parry 2021, 2636).

Marres et al. 2013

- Correct and complete information about casualties is recognized in the study by Marres et al. (2013) to be one of the biggest challenges for coordinated and efficient medical response (Marres et al. 2013, 446, 452).
- Data interoperability is defined as a worldwide problem during mass casualty incidents that hampers communication and information sharing and ultimately effective medical response including triage, patient allocation and transport to target hospitals and hospital preparations (Marres et al. 2013, 446).
- A lack of or ineffective integration of different systems of first responders (Marres et al. 2013, 446).
- Cybersecurity and data ownership issues are addressed with agency specific requirements and authorization and integrated authentication mechanism to verify patient privacy (Marres et al. 2013, 447, 452).
- Human errors due to unfamiliarity with PDAs and ViTTS system and incomplete automatic functions in scanning and switching back to primary network were identified as deficiencies of ViTTS system (Marres et al. 2013, 450).
- Used platforms like ViTTS should be in daily use and not just during mass casualty incidents, the systems require flexibility and secure data exchange, data needs to be clinically-based and the system should automatically generate identification number for each incident (Marres et al. 2013, 452).
- The connection issues and system integrity could be further secured with an extra satellite gateway and in-hospital data integration should be further ensured by training of hospital personnel (Marres et al. 2013, 452).

Norri-Sederholm et al. 2014

- Paramedic field supervisors have four different roles as they act as situation followers, analyzers, planners and decision makers (Norri-Sederholm et al. 2014, 152).
- Paramedic field supervisors need to make quick decisions while receiving constant information and sharing information with other stakeholders (Norri-Sederholm et al. 2014, 157).

Tian et al. 2014

- Challenges related to an MCI are identified as assessing the scale of the MCI and integrating and allocating the available medical resources efficiently (Tian et al. 2014, 2).
- Tian et al. describe paper documents as easy to use but they remark about related deficiencies of those like accuracy and inadequacy of information transmission and problems related to the utilization of information (Tian et al. 2014, 2).
- The START triage and other traditional triage schemas having too static and overlapping categories resulting in poor adaptability for diversity of different incident types and resulting in considerable over-triage and possible misled prioritization of casualties (Tian et al. 2014, 2, 8).

Yang et al. 2012

- Information related problem during an emergency response to include defining the relevant information for different stakeholders, organizing that information to avoid overload and duplication of information and optimal presentation of the information to enable maximum performance for all responders (Yang et al. 2012, 781-782).
- New technology related fear and insecurities of emergency personnel is emphasized by Yang et al. as one problem resulting deficient utilization of all the information available and thus reducing efficiency and accuracy of decision-making processes (Yang et al. 2012, 772, 782).
- Emergency management systems infrequent use in practice and overall utilization only in emergency situations is seen problematic (Yang et al. 2012, 764-765).
- The fragmentation of existing information systems and differentiating needs for information is also described problematic as dynamic information for all responders is described critical for emergency response (Yang et al. 2012, 765).
- Yang et al. point out the difference between working on-site during an emergency response and normal daily operations as the level of cooperation and interaction with other organizations during an emergency response is much more profound. This is generally seen as a lack of trust and understanding between different first responder organizations. (Yang et al. 2012, 765.)
- Yang et al. point out the security risks regarding public communication media-based decision support systems and the general need for reliability and flexibility of decision support systems. The public information communication infrastructure is described being vulnerable to interruptions caused by any kind of attacks or natural disasters. (Yang et al. 2012, 777-778, 783.)

Initial coding

1. The need for pre-established roles and communication and command system including set protocols, standards and terminology (Allen et al. 2014; Lee et al. 2019, Holgersson 2016); a lack of set protocols, procedures and terminology for information exchange (Urquieta & Varon 2014); poor integration of operating procedures (Allen et al. 2014)
2. Security, privacy and trust issues (Allen et al. 2014, Madanian & Parry 2021, Marres et al. 2013, Yang et al. 2012)
3. Allocation of used operating frequencies and transmission standards (Allen et al. 2014); equipment related technical deficiencies, inadequacies and malfunctions (Holgersson 2016); the public information communication infrastructure is described being vulnerable to interruptions caused by any kind of attacks or natural disasters (Yang et al. 2012)
4. Information overload (Allen et al. 2014, Yang et al. 2012); paramedic field supervisors need to make quick decisions while receiving constant information and sharing information with other stakeholders (Norri-Sederholm et al. 2014)
5. A lack of recognized methodology and conceptual framework for gathering, pooling and sharing of information (Allen et al. 2014); the information gathering in incident site is focused to the relevant information for own organization´s processes and response (Allen et al. 2014); challenges related to an MCI are identified as assessing the scale of the MCI and integrating and allocating the available medical resources efficiently (Tian et al. 2014)
6. Pre-established operating systems and work practices need to be integrated into daily operating procedures to secure their usage also during an emergency response (Allen et al. 2014, Madanian et al. 2021, Marres et al. 2013, Yang et al. 2012)
7. A lack of cooperation and information related interplay on-scene between different service providers (Allen et al. 2014, Urquieta & Varon 2014, Yang et al .2012); the flow of information is described vertical and hierarchical within individual organizations and information sharing focusing to the strategic apex (Allen et al. 2014)
8. Command and control functions of different organizations might not be co-located (Allen et al. 2014)
9. Incompatible communication systems, overload of the used equipment due to highly increased demand for use or physical damage to the used communication infrastructure (Holgersson 2016, Marres et al. 2013, Madanian & Parry 2021)
10. A lack of training, routine and inadequate compliance with organizational principles (Holgersson 2016, Marres et al. 2013); new technology related fear and insecurities of emergency personnel (Yang et al. 2012)

11. Noise levels at the incident site (Holgersson 2016), Large incident sites were recognized to cause deficiencies in relaying information between first responders (Holgersson 2016)
12. The need for clear and secure method to document and transfer patient information through the chain of care (Holgersson 2016, Marres et al. 2013, Madanian & Parry 2021, Tian et al. 2014); chaotic disaster situations and misidentification of casualties (Madanian & Parry 2021)

Enhanced coding

1. The need for pre-established roles and communication and command system including set protocols, standards and terminology (Allen et al. 2014, Holgersson 2016, Lee et al. 2019, Urquieta & Varon 2014); poor integration of operating procedures (Allen et al. 2014); a lack of cooperation and information related interplay on-scene between different service providers (Allen et al. 2014, Urquieta & Varon 2014, Yang et al .2012); the flow of information is described vertical and hierarchical within individual organizations and information sharing focusing to the strategic apex (Allen et al. 2014); command and control functions of different organizations might not be co-located (Allen et al. 2014); the need for clear and secure method to document and transfer patient information through the chain of care (Holgersson 2016, Madanian & Parry 2021, Marres et al. 2013, Tian et al. 2014); chaotic disaster situations and misidentification of casualties (Madanian & Parry 2021); pre-established operating systems and work practices need to be integrated into daily operating procedures to secure their usage also during an emergency response (Allen et al. 2014, Madanian et al. 2021, Marres et al. 2013, Yang et al. 2012); security, privacy and trust issues (Allen et al. 2014, Madanian & Parry 2021, Marres et al. 2013, Yang et al. 2012)
2. Allocation of used operating frequencies and transmission standards (Allen et al. 2014); equipment related technical deficiencies, inadequacies and malfunctions (Holgersson 2016); incompatible communication systems, overload of the used equipment due to highly increased demand for use or physical damage to the used communication infrastructure (Holgersson 2016, Madanian & Parry 2021, Marres et al. 2013); the public information communication infrastructure is described being vulnerable to interruptions caused by any kind of attacks or natural disasters (Yang et al. 2012)
3. Information overload (Allen et al. 2014, Yang et al. 2012); a lack of recognized methodology and conceptual framework for gathering, pooling and sharing of information (Allen et al. 2014); security, privacy and trust issues (Allen et al. 2014, Madanian & Parry 2021, Marres et al. 2013, Yang et al. 2012); paramedic field supervisors need to make quick decisions while receiving constant information and

sharing information with other stakeholders (Norri-Sederholm et al. 2014); the information gathering in incident site is focused to the relevant information for own organization´s processes and response (Allen et al. 2014); a lack of set protocols, procedures and terminology for information exchange (Urquieta & Varon 2014); challenges related to an MCI are identified as assessing the scale of the MCI and integrating and allocating the available medical resources efficiently (Tian et al. 2014)

4. A lack of training, routine and inadequate compliance with organizational principles (Holgersson 2016, Marres et al. 2013); new technology related fear and insecurities of emergency personnel (Yang et al. 2012); large incident sites were recognized to cause deficiencies in relaying information between first responders (Holgersson 2016); Noise levels at the incident site can cause problems and delays in information exchange (Holgersson 2016); Human errors due to unfamiliarity with PDAs and ViTTS system (Marres et al. 2013)

Final coding

1. Challenges related to command system, cooperation, communication and operating procedures (Allen et al. 2014, Holgersson 2016, Lee et al. 2019, Madanian & Parry 2021, Marres et al. 2013, Tian et al. 2014, Urquieta & Varon 2014, Yang et al. 2012)
2. Challenges related to communication infrastructure and equipment (Allen et al. 2014, Holgersson 2016, Madanian & Parry 2021, Marres et al. 2013, Yang et al .2012)
3. Challenges in information handling (Allen et al. 2014, Madanian & Parry 2021, Marres et al. 2013, Norri-Sederholm et al. 2014, Tian et al. 2014, Urquieta & Varon 2014, Yang et al. 2012)
4. Challenges related to personnel and incident site (Holgersson 2016, Marres et al. 2013, Yang et al. 2012)