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REVIEW ARTICLE

Key Features in Designing an Integrated Recall System for Dispatch in Mass Casualty Incidents; a Systematic Review

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Abstract: **Introduction:** Following Mass Casualty Incidents (MCIs), the sudden surge in demand for essential services disrupts the balance between available and required resources. This study aimed to systematically identify and categorize existing systems employed for dispatching professional or lay rescuers during emergencies. **Methods:** Adhering to the PRISMA 2020 Checklist, the research scrutinized international databases (PubMed, Scopus, and Web of Science) using formulated search strategies. Additionally, a manual search was conducted on Google Scholar and prominent journals employing specific keywords. Original articles introducing systems for dispatching rescuers to incident sites were included. **Results:** Thirty-one of the 23051 initially identified documents were included for data extraction and quality assessment. The comprehensive analysis revealed twenty-two dispatch systems worldwide, contributing to life-saving efforts in emergencies. Additionally, an evaluation of the articles' quality using the Mixed Methods Appraisal Tool (MMAT) with five scores, indicated that more than two-thirds of the identified articles scored four or higher. Summarizing the data extracted from these systems, four distinct categories of recall system characteristics were identified: general, dispatcher, responder, and other features. **Conclusions:** Technology has the potential to revolutionize the delivery of healthcare services. This study highlights four key elements necessary for the development of dispatch systems that can effectively mobilize healthcare providers to the incident scene. These elements include general characteristics, dispatcher roles, responder requirements, and additional features, which equip researchers with the knowledge for designing effective systems to recall healthcare providers during MCI.

Keywords: Mass casualty incidents; Emergency medical dispatch; Health personnel

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1. Introduction

The World Health Organization (WHO) defines Mass Casualty Incidents (MCIs) as events that result in a substantial number of patients, requiring a departure from regular procedures to effectively manage the situation with the available resources (1). During MCIs, the sudden increase in demand for essential services such as triage, treatment, and transportation disrupts the balance between existing resources and those needed to handle the incident efficiently (2, 3). Therefore, it is imperative to ensure the timely presence of human resources and swift access to necessary equipment at the scene to effectively address such incidents (4). Emergency Medical Services (EMS) globally often encounter challenges related to staffing and resource shortages, compounded by the difficulty of reaching sparsely populated areas to deliver services (5).

Emergency volunteers are pivotal in bolstering the community's ability to respond effectively to incidents. Their close proximity to fellow community members allows them to be the initial responders, saving lives and preventing disabilities during emergencies. This role becomes particularly vital in instances of cardiac emergencies (6). It is imperative to actively involve communities and encourage community-based responses to emergencies, especially in rural and challenging areas where resources may be limited, and geographical access poses difficulties (7).

In numerous countries today, the deployment of smartphone applications, Short Message Service (SMS), and Global Positioning System (GPS) technology has become instrumental in mobilizing trained volunteers and expert human resources to incident sites (8, 9). Noteworthy among these systems are applications such as GoodSam (10), Pulsepoint (11), FirstAED (12), Life Guardians (13), MyResponder (14),

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and Mobile Rescuer (15), which significantly aid volunteers in their relief efforts. The first practical system for dispatching rescuers was implemented in Switzerland in 2006, utilizing a text message-based system (16). Additionally, in 2007, there was a proposal to employ mobile phone software for contacting off-duty trained and volunteer employees, to enhance the chain of survival in out-of-hospital emergencies (17).

As previously highlighted, the shortage of human resources emerges as a significant challenge following MCI. An identified solution to tackle this concern involves the implementation of dispatch systems designed to mobilize healthcare providers and other rescuers to the scene of MCI. The objective of this study is to conduct a systematic review to identify and categorize existing systems employed for dispatching professional or lay rescuers during emergencies. Through a thorough analysis of the key features of these systems, the researchers aim to make a valuable contribution to the development of a comprehensive system that efficiently dispatches health care providers to the scenes of incidents involving MCI.

2. Methods

2.1. Study design and setting

This systematic review commenced its activities after obtaining ethical approval from Shahid Sadoughi University of Medical Science under the code (IR.SSU.SPH.REC.1401.108). It is noteworthy that the study adhered to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 Checklist. Furthermore, the study protocol has been registered in the PROSPERO system and assigned the PROSPERO code (CRD42022367642). The study aimed to identify the currently employed systems for dispatching professional or lay rescuers during emergencies. The secondary objective involves extracting and classifying the key features inherent to these identified systems.

2.2. Eligibility criteria

In this systematic review, articles of all types were considered for inclusion, except for those categorized as review, systematic review, meta-analysis, editorial, congress proceeding, lecture, conference proceeding, letter, and commentary. The focus was on articles introducing a system for dispatching rescuers to the incident site. Articles describing dual dispatch scenarios, where emergency forces, the fire brigade, and the police were simultaneously called through the medical emergency center without utilizing a specific dispatch system, were excluded. The selection of studies was not restricted by language or time frame.

2.3. Data gathering

An electronic search was conducted on databases such as PubMed, Scopus, and Web of Science (WOS), without imposing any time restrictions. To ensure comprehensive coverage of relevant articles, a manual search on Google Scholar was also performed using specific keywords. The search extended to prominent journals in the field, identified through the results of the initial article search. Furthermore, the reference lists of articles included in this systematic review were scrutinized for additional relevant studies. This combined approach aimed at encompassing a broad spectrum of literature on the subject.

The features extracted from dispatch systems are categorized into four main areas: general, dispatcher, responder, and other features. In instances of disagreements, expert group discussions were employed to resolve any discrepancies and ensure consensus.

2.4. Search strategy

To formulate the search strategy, an initial step involved studying several related articles, from which keywords were extracted. These keywords were then searched within the Medical Subject Heading (MeSH) of the PubMed database, and entry terms for these words were identified. Subsequently, the search strategy was crafted for the PubMed database. The results obtained from the PubMed search were meticulously examined and analyzed by reviewing the titles and abstracts of 100 primary articles. The pilot phase provided the PubMed number needed to read (NNR). Following this, the search strategy for both Scopus and Web of Science databases was adjusted under the respective principles of each database. The syntax used for each database is as follows:

PubMed

("emergency medical dispatch"[MeSH Terms] OR "dispatch*"[Title/Abstract] OR "deployment"[Title/Abstract] OR "redeployment"[Title/Abstract] OR "summon"[Title/Abstract] OR "notif*"[Title] OR "message"[Title] OR "recall"[Title] OR "re call"[Title] OR "app"[Title] OR "communication system*"[Title/Abstract] OR "hospital communication"[Title/Abstract] OR "communication hospital"[Title/Abstract] OR "hospital communication systems"[MeSH Terms] OR "ems communication"[Title/Abstract] OR "telecommunication*"[Title/Abstract] OR "Telegraphy"[Title/Abstract]) AND ("health personnel"[MeSH Terms] OR "health personnel"[Title/Abstract] OR "health care provider*"[Title/Abstract] OR "healthcare provider*"[Title/Abstract] OR "healthcare worker*"[Title/Abstract] OR "health care worker*"[Title/Abstract] OR "health care professional*"[Title/Abstract] OR "volunteers"[MeSH Terms] OR "volunteer*"[Title/Abstract] OR "voluntary worker*"[Title/Abstract] OR "volunteer worker*"[Title/Abstract] OR "volunteer personnel"[Title/Abstract] OR "Volunteerism"[Title/Abstract] OR "untrained personnel"[Title/Abstract] OR "lay rescuer*"[Title/Abstract] OR "lay responder*"[Title/Abstract] OR "lay people"[Title/Abstract] OR "Emergency Re-

sponders"[MeSH Terms] OR "emergency responder*"[Title/Abstract] OR "first responder*"[Title/Abstract])
Scopus
TITLE-ABS-KEY(dispatch*) OR TITLE-ABS-KEY(deployment) OR TITLE-ABS-KEY(redeployment) OR TITLE-ABS-KEY(summon) OR TITLE(notif*) OR TITLE(message) OR TITLE(recall) OR TITLE(re-call) OR TITLE(app) OR TITLE-ABS-KEY("communication system*") OR TITLE-ABS-KEY("hospital communication") OR TITLE-ABS-KEY("communication hospital") OR TITLE-ABS-KEY("ems communication") OR TITLE-ABS-KEY(Telecommunication*) OR TITLE-ABS-KEY(Telegraphy) AND TITLE-ABS-KEY("health personnel") OR TITLE-ABS-KEY("health care provider*") OR TITLE-ABS-KEY("healthcare provider*") OR TITLE-ABS-KEY("healthcare worker*") OR TITLE-ABS-KEY("health care worker*") OR TITLE-ABS-KEY("health care professional*") OR TITLE-ABS-KEY(volunteer*) OR TITLE-ABS-KEY("voluntary worker*") OR TITLE-ABS-KEY("volunteer worker*") OR TITLE-ABS-KEY("volunteer personnel") OR TITLE-ABS-KEY(Volunteerism) OR TITLE-ABS-KEY("untrained personnel") OR TITLE-ABS-KEY("lay rescuer*") OR TITLE-ABS-KEY("lay responder*") OR TITLE-ABS-KEY("lay people") OR TITLE-ABS-KEY("Emergency Responder*") OR TITLE-ABS-KEY("First Responder*")
Web of Science
(TS=("Dispatch*") OR TS = ("deployment") OR TS = ("redeployment") OR TS = (summon) OR TI = ("notif*") OR TI = ("message") OR TI = ("recall") OR TI = ("re-call") OR TI = ("app") OR TS = ("communication system*") OR TS = ("hospital communication") OR TS = ("communication hospital") OR TS = ("ems communication") OR TS = ("Telecommunication*") OR TS = ("Telegraphy")) AND (TS = ("health personnel") OR TS = ("health care provider*") OR TS = ("healthcare provider*") OR TS = ("healthcare worker*") OR TS = ("health care worker*") OR TS = ("health care professional*") OR TS = ("volunteer*") OR TS = ("voluntary worker*") OR TS = ("volunteer worker*") OR TS = ("volunteer personnel") OR TS = ("Volunteerism") OR TS = ("untrained personnel") OR TS = ("lay rescuer*") OR TS = ("lay responder*") OR TS = ("lay people") OR TS = ("Emergency Responder*") OR TS = ("First Responder*"))

To keep researchers informed about potential publications throughout the review process, an alert has been integrated into the researcher's profile. This innovative feature allows researchers to stay up-to-date with articles that are likely to be published, thereby enhancing their awareness and productivity during the review process.

2.5. Selection process

The relevant documents obtained were systematically categorized in Endnote version 20 (Clarivate, Philadelphia, USA). Following the removal of duplicates, two researchers independently examined the titles and abstracts of the identified studies. The full texts of these studies were subsequently scrutinized in line with the objectives of this systematic review. In cases of disagreement between the researchers, thorough discussions were conducted in a group setting, ensuring a collaborative and professional approach to problem-solving. The method employed for identifying and extracting related articles is illustrated in Figure 1, according to the PRISMA 2020 flow diagram.

The articles incorporated into this systematic review underwent thorough examination utilizing a prepared checklist in Microsoft Excel Version 2013 (Microsoft Corporation, Washington, USA). Subsequently, the required data from these articles were meticulously extracted. The researchers adopted a collaborative approach to segregate and input the data from these articles. The information extracted from the articles is systematically organized and presented in Tables 1 through 5.

2.6. Risk of bias assessment

Given that no restrictions were imposed on the type of articles included in this study, the risk of bias was assessed using the Mixed Methods Appraisal Tool (MMAT) developed at McGill University to evaluate the quality of articles (18). This tool allows for the evaluation of quantitative, qualitative, and mixed-method studies. The scoring method categorizes studies into five different categories based on their empirical nature: qualitative studies, randomized controlled quantitative studies, non-randomized quantitative studies, quantitative descriptive studies, and mixed-method studies. If a study does not meet the criteria for an empirical study, it is not considered as such. Each category has its own set of criteria, which are explained in detail. The grading is done using a scale of (*, **, ***, ****, and *****) at the end of table 1. The scale indicates that (*) represents the lowest level of evaluation, while (*****) signifies the highest quality.

3. Results

Based on the initial search conducted until June 2024, a comprehensive analysis was performed on 23051 documents across three primary databases: PubMed, Scopus, and Web of Science. Following the removal of duplicate entries and the application of exclusion criteria, the pool was refined to 10475 documents. A meticulous review and screening process, focusing on titles and abstracts, led to the selection of 102 articles for an in-depth full-text examination.

Upon a careful re-evaluation aligned with the systematic review's objectives, twenty-four articles were identified as relevant and subsequently included in the study. Additionally, seven articles were incorporated through searches on Google Scholar (five) and scrutinizing the references of pertinent articles (two). Throughout the study's progression, the search databases were consistently monitored, and any pertinent search notifications were verified.

It is imperative to highlight that language restrictions were not imposed in the search strategy, resulting in the inclusion of an article written in German (15). For the execution of this systematic review, a total of thirty-one articles, spanning the years 2011 to 2024, underwent a thorough examination. These articles presented and assessed twenty-two dispatch systems designed to provide life-saving support during emergencies. Furthermore, an assessment of the articles' quality using the MMAT tool revealed that over two-thirds of the identified articles scored four or higher. Notably, some systems were covered in multiple articles, and a detailed breakdown of these articles is presented in Table 1.

3.1. General features

The identified systems span across various countries, each contributing to emergency response initiatives. Noteworthy systems include those from Denmark, such as FirstAED (9, 12), SimaGo (19), and Heartrunner (20). In the USA, systems like Save A Victim Everywhere (SAVE) (21), UnityPhilly (22), and PulsePoint (11, 23, 24) play a crucial role. Sweden is represented by the Mobile Lifesaver Service (25, 26)and the lay-responder system (27).

Japan introduces the prototype simulation CFR dispatch system (28) and AED-SOS (29), while England features GoodSAM (10, 30). Singapore contributes to MyResponder (14), and Israel is represented by The Life Guardians (13, 31). Ireland showcases MERIT 3 (32, 33), and Switzerland introduces an APP-based alert system (16). The Netherlands is included with the TM-alert system (34-36), and Germany features Mobile-Rescuers (15). Korea adopts a Text message alert system (37), France incorporates Staying Alive (38), and Spain contributes a Smartwatch application (39). Belgium introduces EVapp (40), and Bangladesh is represented by TraumaLink (41). These diverse systems collectively form a comprehensive landscape of global initiatives in the field of emergency response.

Among the four highlighted systems [Prototype simulation CFR dispatch system (28), AED-SOS (29), SAVE (21), Smartwatch application (39)], it is crucial to emphasize that they are presently undergoing the prototype simulation phase and have not been deployed for operational use. The transmission of messages across various systems can be achieved through diverse methods and approaches. Switzerland's APP-based alert system, for instance, has utilized the text message platform since 2006, and the application platform has been incorporated into the system in addition to the text message since 2014 (16). In total, two types of platforms are employed, including text messages and applications. Among the fifteen systems designed on the application platform, the FirstAED (12) system and Smartwatch application (39) are specifically tailored for IOS and Android operating systems, respectively. The remaining systems are designed to be compatible with both operating systems, as outlined in Table 2.

One of the distinctive features of these systems is the authorization for rescuers to operate in public, residential, or both environments. Fifteen systems have received approval to function in both public and residential settings, while five systems are exclusively permitted for operation in public places. Additionally, two systems have implemented their prototypes specifically in residential homes, as outlined in Table 2. Notably, the PulsePoint system, initially active in public environments, underwent a significant update in 2017. This update extended the system's capabilities, allowing a number of professional health care providers to make calls and conduct consultations in residential settings as well (23).

In terms of system activity duration, it is noteworthy that the TM-alert system (34), APP-based alert system (16), EVapp (40), and PulsePoint (23) operate continuously, providing services 24 hours a day, 7 days a week. Conversely, four systems have specified designated operational hours during the day. However, several other systems lack explicit information regarding the duration of their activity, whether during the day or night.

These General features are detailed in Table 2.

3.2. Dispatcher features

Consideration must be given to the device or center responsible for sending notifications, the criteria governing system activation, and whether this activation is performed automatically or manually.

Exceptions include the GoodSAM (10), UnityPhilly (22), and AED-SOS (29) systems, which empower bystanders to directly call for help through the systems and the local dispatch center. Conversely, most other systems only permit the local dispatch center to request assistance from volunteer rescuers through the pre-hospital emergency system. The TraumaLink system employs a dedicated contact number (TraumaLink call center) for this purpose (41). Notably, the Smartwatch application, included in this study, adopts a unique approach by activating the alarm in the absence of a heartbeat or if a patient falls. If the alarm is not deactivated within three seconds, an alert is sent from the patient's smartwatch app to volunteers' smartphone apps within a 300-meter range and the platform installed in the EMS center (39) (Table 3).

Activation criteria vary based on the specific objectives of system implementation in different events. Of the twenty-two identified systems, fifteen are dedicated to responding specifically to the Out of Hospital Cardiac Arrest (OHCA) incident. UnityPhilly focuses on drug overdose incidents (22), while TraumaLink addresses road incidents and has recently expanded to include other types of medical emergencies (41). Additionally, five systems are designed to specifically handle cardiac events, including other medical emergencies like MCI (Table 3).

Moreover, age is a significant activation criterion in several systems. Four systems specify the call system is for adults and won't activate for children under the age of eight. SimaGo restricts activation for children under seven (19), and the Text message alert system limits activation for children under eighteen (37). Only the GoodSAM system indicates the ability to call both adults and children (10) (Table 3).

In addition to the age limits, systems mention other causes for non-activation. These include non-cardiac causes of cardiac arrests, trauma or suicide (reported in six cases), incidents in dangerous environments (five cases), close proximity of an ambulance to the incident scene or ambulance witnessed (four cases), and lack of a clear address (one case) (Table 3).

A noteworthy feature of the Dispatch center is its capability to automatically activate the system simultaneously with EMS dispatch, observed in three systems. Conversely, other systems necessitate manual activation by the operator based on prevailing conditions (Table 3). Furthermore, in the seventeen recognized systems, rescuer selection is efficiently automated based on pre-established configurations. Five systems mention that the dispatch center operator can intervene in rescuer selection, if necessary, based on prevailing conditions (Table 3).

The process for locating and dispatching rescuers to incident sites involves utilizing GPS or pre-registered addresses to automatically calculate the distance between the rescuer and the incident site, based on the bystander's contact information. Subsequently, the system reaches out to the closest individuals within a specific range or to all individuals in the vicinity.

The findings of the present study reveal that the TM-alert system (34), Text message alert system (37), and TraumaLink (41) measure the position and distance of rescuers from the incident site based on predetermined addresses, while other systems rely on information obtained from GPS for positioning. The app system in Belgium employs two methods to locate rescuers effectively. Initially, it uses GPS technology to pinpoint the rescuer's location. If there is no response within a certain distance, the system then checks the registered addresses of the rescuer's workplace and residence (40). In such cases, it initiates a search to locate the rescuer and alerts nearby individuals via SMS.

Additionally, the SAVE system sends help requests to all volunteers regardless of their location and estimated distance (21).

Another notable dispatcher feature of emergency dispatch systems is determining the Maximum Activation Radius to select the closest emergency responders. This distance varies from 200 meters to 5000 meters on foot and up to 10 km by car. In certain systems, this distance can be variable and adjusted by the operator. Alternatively, it may not have a specific numerical value, and the decision to modify the distance is based on comparing the estimated arrival time of EMS and the maximum estimated arrival time of rescuers at the incident scene (Table 3).

The number of rescuers summoned to the incident scene varies across systems. For instance, SimaGo (19) and MobileRescuers (15) systems summon two people, while the TM-alert system can call up to 30 to the scene of the incident (34). Eleven systems mention calling all available volunteers within a specified range (Table 3). It's important to note that the number of individuals summoned can vary based on the system's location within a city or different countries. For example, the GoodSAM system in England adopts different approaches, calling three people in London compared to five people in East Midland (10). Additionally, even within a single area, a specific system may adopt different approaches in various incidents. In Israel, the Life Guardian system increases the identification range of volunteers in MCIs by expanding the radius (13).

Another noteworthy facet of the examined systems is the maximum time allocated for rescuers to respond to a help request message. This feature is of paramount importance as it ensures that the crucial golden response time is utilized efficiently, providing other potential rescuers with an opportunity to respond. Interestingly, the specified time limits vary, ranging from a swift 20 seconds and 35 seconds to a somewhat more lenient 2 minutes, as detailed in Table 3.

Another notable feature in systems designed to summon rescuers to incident sites, particularly those specialized in Out of Hospital Cardiac Arrest (OHCA), is their integration with the identification database of registered Automated External Defibrillators (AEDs) in the vicinity. These systems accurately identify and locate nearby AEDs, providing crucial information to rescuers at the scene. Additionally, eight dispatch centers allocate specific roles to rescuers, suggesting that those closest to the AED device retrieve it and proceed to the patient, while others head directly to the patient. For example, the MyResponder system delivers AEDs promptly using taxis (14), and in systems like SimaGo (19) or MERIT3 (32), responders equipped with AEDs in their vehicles are deployed.

These dispatcher features are detailed in Table 3.

3.3. Responder features

Various rescuers contribute to different systems, encompassing off-duty healthcare professionals, lay rescuers, off-duty firefighters, and community first responders (CFRs). Recruitment methods involve diverse approaches such as newspaper advertisements, websites, social media, television campaigns, and citywide posters to encourage cooperation. Examples include the MERIT3 system inviting General Practitioners (GPs) (32), SimaGO selecting and inviting home care providers through the municipality (19), and TraumaLink engaging individuals living around highways (41).

The importance of training rescuers is a common consideration in these systems. Notably, not all systems require mandatory training. For instance, both the PulsePoint (11) and Heartrunner (20) systems do not require a training certificate. However, an impressive 84% and 98% of individuals in these systems, respectively, have voluntarily completed training programs. The MyResponder system accepts individuals based on their self-declaration of readiness to participate without necessitating confirmation of special training courses (14). The GoodSAM system facilitates the registration of relief organizations on the platform, allowing them to confirm the membership of professional forces under their organization (10).

In this study, all identified systems were voluntary, allowing rescuers the autonomy to accept or decline aid as they see fit (Table 4).

Among the identified systems, nine of them empower rescuers to specify their status, enabling dispatch center operators to ascertain whether the rescuer is actively responding or currently unavailable. In the prototype simulation CFR dispatch system, rescuers can proactively communicate their readiness by selecting options like 'dispatch possible,' 'dispatch impossible,' 'dispatched,' or 'arrived' (28). In UnityPhilly, once an alarm is received, responders can promptly choose between two states: En-route or Can't go (22), facilitating swift decision-making.

Another responder feature of the identified dispatch systems is the capability to track and determine the location of other rescuers. This enables rescuers to monitor both fellow rescuers and official Emergency Medical Services (EMS) forces, providing real-time information on their position and quantity. Systems like GoodSAM (10), The Life Guardians (13), and UnityPhilly (22) have incorporated this capability into their application platforms.

In terms of communication the responder with the dispatch center during a mission, if necessary, various systems offer diverse options. For example, the GoodSAM system facilitates video calls (10), while the UnityPhilly system takes it a step further, providing not only video calls but also the capability to engage in chat conversations with the signal center and fellow rescuers (22). Moreover, eight other systems have indicated the availability of voice calls between the rescuer and the dispatch center (Table 4).

A crucial feature mentioned by ten systems is the ability to receive a report from the rescuer after a mission. Notably, the MyResponder system allows users to send photos or videos to the dispatch center, facilitating comprehensive reporting of their mission (14).

Among the identified systems, only the Mobile Lifesaver Service operates rescuer without any equipment (25). In contrast, the other twenty-one systems mention various types of first aid and resuscitation equipment, either in the possession of the rescuer or with access provided to the rescuer (Table 4).

The most frequently mentioned equipment across the systems is the AED, integrated into the dispatch process by seventeen systems.

However, the methods of accessing this device vary among the systems. In fifteen systems, the information bank containing the location of AEDs in a region is linked to the recall system, and if needed, the address of the nearest devices is made available to the rescuer in the system as a map link. The MERIT3 (32) and SimaGo (19) systems equip rescuers with an AED and a bag of protective equipment, including gloves, which they carry in their vehicles. Moreover, the MyResponder system not only locates AED devices but also utilizes taxis in the city to swiftly transport the defibrillator to the incident site (14) (Table 4).

Beyond AED devices, various systems employ additional equipment. For example, the Life Guardian system provides a kit with essential first aid equipment, including a mask, airway, and tourniquet. It is noteworthy that the contents of this kit differ for professional rescuers and lay rescuers (13). Additionally, the Mobile-Rescuer system, which relies on professional volunteers, mentions masks and gloves as the primary equipment used in this system (15). The TraumaLink system is recognized for placing first aid kits in locations accessible 24/7 (41). In terms of medical equipment, the American UnityPhilly system enables volunteers to carry a kit containing two doses of nasal naloxone. The system also displays the location of pharmacies equipped with this drug within the app, allowing rescuers to acquire it if necessary. These volunteers have undergone training on how to administer the medicine and its indications (22).

These response features are detailed in Table 4.

3.4. Other features

Legal considerations are a prominent focus across all systems, emphasizing the voluntary nature of rescuer participation without any obligation to accept missions. However, two systems, Mobile-Rescuers (15) and SimaGo (19), explicitly state that accepting a rescue mission doesn't grant permission to violate traffic laws, emphasizing the need for rescuers to adhere to rules and speed limits.

A crucial legal aspect highlighted in the Mobile Lifesaver Service (25) is the commitment expected from rescuers to maintain patient confidentiality. Additionally, ensuring permission and proper handling of real-time location tracking information of rescuers are emphasized in the Mobile-Rescuers system (15).

Insurance coverage is explicitly mentioned in only five systems (Table 5). The PulsePoint system specifies that professional rescuers, when verified and considered as such, will be contractually provided compensation and liability protection by their employer organization for off-duty responses (23). The MyResponder system clarifies that rescuers hold no obligation or legal responsibility for injuries, such as broken ribs, occurring during cardiopulmonary resuscitation (CPR) (14).

Notably, none of the systems mentions financial or other advantages for rescuers, and there is no explicit mention of ethical issues, complaints, or abuse in any system.

These other features are detailed in Table 5.

4. Discussion

The effective response to incidents heavily depends on the organized deployment of resources, especially specialized human expertise. Achieving this requires responding organizations to prioritize the development of rescuer dispatch systems that are not only precise but also practical in the face of incidents and disasters. Drawing from the experiences garnered through diverse recall systems is instrumental in advancing this objective.

The study's findings underscore the diverse nature of recall systems, which have been published as original articles, scoring rather high in the MMAT evaluation index (Table 1). The results indicate the identification and categorization of four main areas: general, dispatcher, responder, and other features (Tables 2-5).

The study's findings suggest that current recall systems predominantly prioritize the use of application platforms for calls and notifications. However, some systems depend solely on SMS, while others employ both methods. A comparative analysis in Switzerland revealed that the application platform resulted in a quicker response time (28%) compared to SMS (17%), leading to faster initiation of resuscitation efforts and improved outcomes, including a higher survival rate (16). While the trend leans towards application-based communication, maintaining the ability to send SMS acts as a backup in scenarios where internet access on mobile phones is unavailable.

Apart from the chosen platform, the notification reception method is equally significant. Numerous systems employ not only text notifications but also incorporate voice alarms (25, 27, 31), enhancing the effectiveness of message delivery. The GoodSAM system, for instance, experienced instances where volunteers didn't notice text messages, emphasizing the importance of an audible alarm (10, 30). Additionally, the PulsePoint system introduced a silence override feature in its December 2018 update to mitigate non-response during silent mode, further addressing potential notification challenges (23).

The study's findings reveal that the majority of systems predominantly utilize GPS, a cloud-based location service, to identify rescuers within a specified radius of activity, estimating their distance from the incident site. Additionally, a few systems opt for registering people's postal addresses in a database to locate rescuers and the rescuer will receive the address of the incident site in text form. However, it is crucial to recognize that employing this second method presents challenges, including the lack of accuracy in transmitting text addresses and the absence of a guide map to precisely pinpoint the incident's location.

It is noteworthy that despite the growing prevalence of location services, some countries, such as South Korea, impose legal restrictions on tracking individuals' locations using GPS (37).

Moreover, it is crucial to consider the domain of the system's activity. Research indicates that over 70% of OHCA incidents take place in residential areas (21, 42). Additionally, the rate of survival in cardiac incidents has seen a significant increase since the system's implementation in homes (36, 42). This enhanced performance in residential settings during OHCA incidents may be attributed to the higher frequency of emergencies in such areas and potential delays in the arrival of emergency services. However, it appears that widely used systems like Life Guardians, which handle not only cardiac incidents but also other events like MCI, primarily concentrate on public areas with high foot traffic and congestion (13). Therefore, when designing a recall system, it is imperative to define the scope of its activity while considering the intended purpose of the system.

The efficacy of the system is not only contingent on its operation within indoor or outdoor environments but is also influenced by population density, distinguishing between urban and rural settings. An enlightening study underscores that despite fewer volunteers in rural areas, the extended response time of emergency services allows volunteers to potentially reach the incident scene earlier (43).

Delving into dispatcher features, this study explores the selection of an appropriate distance between the rescuer and the incident scene.

Concerning the GoodSAM system, findings reveal several influencing factors. Despite the disparity in the maximum radius between London (500m) and East Midlands (800m), increasing this distance results in a higher number of activated alarms. However, this expansion does not significantly impact the level of acceptance and response from system volunteers (30). To accurately determine the optimal radius, it is imperative to consider not only the number of active individuals within the system but also the mode of transportation (foot or car) and the geographical features of the area. The nature of the incident is also important in radius determination. For instance, in the Life Guardians system, volunteers are mandated to reach the scene within five minutes for everyday incidents. Conversely, in the case of MCI, this radius can be extended (13). Therefore, when configuring the system for MCI-related scenarios, it is crucial to acknowledge that the radius of the system's activity may differ and even surpass that of incidents involving OHCAs. This variation is attributed to the greater number of responders required due to the higher count of injured individuals, thus necessitating a more extensive and adaptable response operation.

Emphasizing the significance of dispatch center considerations, Brooks et al. (11) posit that various technical factors can hurt recall systems.

These factors encompass the volume of notifications, the accuracy of GPS positioning, the choice of an unsuitable activity radius, an inadequate number of responders, and an inappropriate trigger for accurate incident identification.

In the context of selecting an appropriate trigger, it is noteworthy that various systems examined in this study exhibit a notable incidence of false alarms. Notably, the lay-responder system manifests a false alarm rate of 66%, indicating that only three out of ten OHCA incidents are accurately identified (27). Similarly, in the case of MERIT3, only 30% of the missions were verified as genuine OHCA cases (33). This scenario can be discouraging for volunteers and emphasizes the imperative need for a specific and up-to-date protocol to precisely identify emergency cases for triggering purposes.

Moreover, it is imperative to regularly reassess system performance guidelines. For instance, in the aftermath of the

COVID-19 pandemic, essential adjustments should be made, such as the provision of personal protective equipment for responders (44) or prioritizing chest-compression-only techniques (45).

The perilous circumstances presented by the pandemic have impacted the activation of numerous recall systems, highlighting that hazardous environments serve as a cautious criterion for mobilizing volunteers. Although Andelius et al.'s study (46) indicates that the risk of physical injury to volunteer responders during activations for OHCA incidents in Denmark is minimal, it's crucial to recognize that these findings are specific to OHCA incidents. They do not encompass other categories of incidents, such as traumatic events and MCI. Beyond physical harm, it is essential to recognize the potential for psychological repercussions, encompassing anxiety and post-traumatic stress disorder (PTSD). According to Kragh et al. (47), the most significant risk factors for psychological injury in volunteers include a lack of prior CPR training, young age, female sex, engagement in CPR operations, and arriving before EMS. It seems that sending a report after a mission and rescuer's follow-up offers the valuable benefit of assessing individuals' physical and psychological distress (48).

The overarching objective of entire recall systems is to expedite access to patients and execute crucial procedures within the critical golden time. Consequently, when formulating a recall system for incidents, particularly in the context of MCI, it becomes pivotal to identify critical areas and high-risk locations within society. This involves recognizing vulnerable patients residing in nursing homes and pinpointing hotspots and areas with a high incidence of traffic accidents. Such identification allows for the strategic deployment of volunteer responders close to these areas, as exemplified by the Traumalink system in Bangladesh, which has demonstrated remarkable results in enhancing response times to traffic incidents. In this system, volunteers are meticulously selected from residents living near the accident-prone highways, ensuring a swift and efficient emergency response (41).

Conversely, Ringh et al. (25) concede in their study that the greater the number of volunteers close to the patient, the higher the likelihood that rescuers will reach the incident scene before EMS. This approach is also adopted by the Life Guardians and Traumalink systems in the context of MCI, where the radius for selecting rescuers is expanded to ensure a more comprehensive and rapid emergency response (13, 41).

Apart from the quantity of rescuers, the speed of their arrival is also contingent on the system activation algorithm and the selection process.

Among the systems scrutinized, both automatic and manual methods were utilized for activating the systems and selecting rescuers. As mentioned earlier, the automation of system activation notably expedites operational workflows. For instance, in the case of the automatic PulsePoint system, rescuers managed to reach the incident site 30 seconds earlier than EMS. However, it is crucial to acknowledge that this automation might lead to a reduction in event specificity and an increase in the false alarm rate (24).

However, when dispatch operators manually select volunteers, the system can substantially enhance service quality by allowing the choice between lay rescuers and professional rescuers within the same geographic area. Validating these findings, a study indicates that individuals with more educated neighbors are more likely to survive and be offered assistance during cardiac arrest incidents (49).

The availability of emergency equipment is a crucial factor influencing the quality of service delivery. Based on the insights gleaned from this study, which identified seventeen recall systems, it becomes imperative to underscore the importance of OHCA-specialized recall systems that prioritize access to AEDs. Hence, when considering the incorporation of this feature into the system, meticulous attention should be directed towards factors such as ensuring an adequate number of AED devices and assessing the financial implications.

In the assessment of equipment used in various recall systems, it is noteworthy that the UnityPhilly system stands out as the only one proposing the use of medication, specifically nasal naloxone, as a primary tool (22). The findings from this study suggest that, currently, pharmaceutical interventions do not play a prominent role not only in systems designed specifically for OHCA, but also in those operating in all emergencies. The inclusion of tools such as tourniquets, airways, and bandages in responders' kits suggests a prioritization of measures like bleeding control and ensuring open airways. This focus on bleeding control is further substantiated by examining measures taken by systems specializing in traumatic events (41).

In the responder's domain, the efficacy of employing incentives for volunteers within recall systems has received limited attention. In a qualitative study, Timmons et al. recognized that individuals volunteer for diverse reasons, encompassing a desire to engage in humanitarian work, acquire experience for future careers, and enhance self-confidence. Financial considerations also wield a substantial influence in shaping their decision-making (50).

Moreover, the incorporation of insurance or legal support for rescuers can significantly enhance the appeal and functionality of these individuals within the system. Upon reviewing the analyzed systems, it is evident that among the five systems providing insurance coverage for volunteer rescuers, three exclusively engage professionals within their framework (15, 23, 32). In Italy, the Italian Resuscitation Council (IRC) advocates for the enactment of a law as part of the Systems Saving Lives (SSL) guideline. This proposed law includes provisions to ensure legal protection for lay rescuers (51). Such initiatives underscore the importance of both insurance coverage and legal safeguards to alleviate concerns and actively encourage individuals to participate in rescue operations. Moreover, a frequently underestimated aspect in the functioning of these systems, necessitating legal consideration, is the establishment of trust among individuals towards unfamiliar rescuers. This becomes particularly crucial in scenarios like home visits, where apprehensions about potential theft or abuse may arise. To mitigate this concern and foster trust between strangers and those in need of assistance, it has been observed that trained volunteers in Bangladesh are equipped with an ID card featuring their photo and profile, along with a fluorescent vest displaying the TraumaLink logo (41). Finally, as previously mentioned, the predominant focus of recall systems is on incidents involving OHCA, with limited attention dedicated to designing and implementing specific systems tailored for MCI. In the scoping review study conducted by Valeriano et al. (52) the available technologies for recall only in OHCA have been examined.

To address this gap, when scrutinizing existing recall systems, it is imperative to also consider the primary needs and existing capacities of the target community. In support of this perspective, Chalikro et al. (53) in Thailand introduced a community-based prehospital service management model led by volunteers, comprising three core phases: needs assessment to evaluate the current situation and understand the socio-cultural context of the society, capacity building to identify suitability, and evaluation. The strength of this model lies in its extraction from the heart of the society itself, in contrast to others presented by government organizations. To ensure the practicality and efficacy of the system, it is crucial to address the challenges associated with its implementation alongside the fundamental design. Additionally, it is imperative to acknowledge the cultural, linguistic, and gender-related challenges faced by rescuers when delivering assistance and services, particularly in rural and remote areas. Unfortunately, the systems identified in this study have given scant attention to this crucial factor. For instance, the AED-SOS system notes that the significant difference in AED usage between women and men should be considered in volunteer selection (29). Similarly, the Traumalink system outlines actions such as negotiations with local religious and civil leaders, as well as family members of potential volunteers, to overcome cultural and religious barriers that may discourage women from participating (41). Therefore, addressing these challenges and evaluating them in alignment with the cultural, social, and economic characteristics of the society in which the emergency recall system will be implemented is essential.

5. Limitations

Despite our endeavor in this study to identify all systems for recalling rescuers to the incident scene through a systematic review method, it is essential to acknowledge that we cannot assert the identification of all existing systems. This limitation arises from instances where systems may not have been published for various reasons, or their introduction may have taken the form of a letter to the editor (54). To address this, we recommend conducting review studies that consider grey literature to ascertain if there are reports available in sources beyond reliable scientific databases.

6. Conclusions

Technology can open a new window for the provision of health care services. By identifying and examining emergency dispatch systems, this research aimed to offer a comprehensive understanding of the current technological landscape. This study highlighted four key elements necessary for the development of dispatch systems that can effectively mobilize healthcare providers to the incident scene. These elements include general characteristics, dispatcher roles, responder requirements, and additional features. The findings of this study could be used to enhance existing recall systems and may also be informative for possible future developers of new rescuer recall systems in MCI.

7. Declarations

7.1. Acknowledgements

None.

7.2. Conflict of interest

The authors declare no conflict of interest.

7.3. Funding and support

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7.4. Authors' contribution

Study design and writing protocol by all authors, data collection and data extraction by (N.M) and (MR.Kh), drafting of the abstract by (MR.Kh), Supervision of methodology by (O.Y), Writing an original draft of the manuscript by (N.M), (S.FA) and (MR.Kh), Investigation, review and editing by (O.Y).

7.5. Data Availability

The authors guarantee that data from the study are available and will be provided if anyone needs them.

7.6. Using artificial intelligence chatbots

The authors declare that they have not used artificial intelligence.

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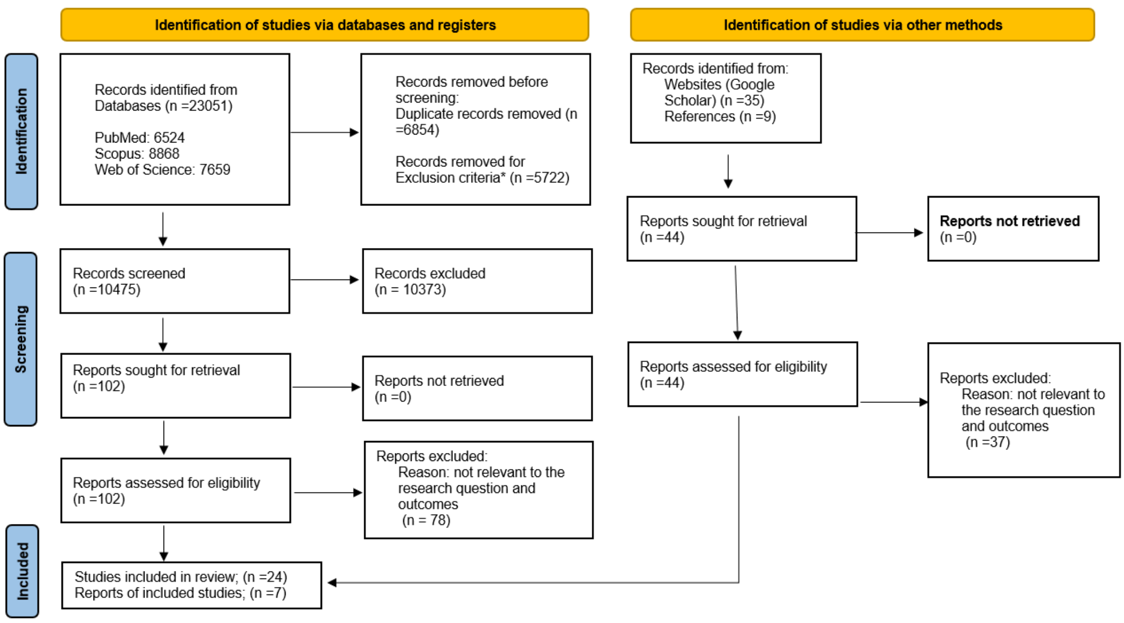

Figure 1: Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 flow diagram. *Exclusion criteria: review, systematic review, meta-analysis, editorial, congress proceeding, lecture, conference proceeding, letter, and commentary.

Table 1: Comparing the baseline characteristics of patients in intervention and control groups

System Name	Reference Number	Author(first)	Journal	Publication Year	Study Design[1]	Language	MMAT SCORE[2]
GoodSAM	10	Christopher M. Smith	Resuscitation	2017	Quantitative descriptive	English	Not an empirical study
	30	Christopher M. Smith	European Heart Journal	2022	Quantitative non-randomized	English	***
TM-alert system	34	Jolande A. Zijlstra	Resuscitation	2014	Quantitative non-randomized	English	***
	35	Ruud W.M. Pijls	Resuscitation	2016	Quantitative non-randomized	English	*****
	36	Ruud W.M. Pijls	European Heart Journal	2017	Quantitative non-randomized	English	*****
Prototype simulation CFR dispatch system	28	Chikara Yonekawa	Journal of Telemedicine and Telecare	2014	Quantitative non-randomized	English	***
Mobile Lifesaver Service (MLS)	25	Mattias Ringh	Resuscitation	2011	Quantitative non-randomized	English	***
	26	Mattias Ringh	The New England journal of medicine	2015	Quantitative randomized controlled trials	English	****
The lay-responder system (Mobile Lifesaver Service in App)	27	Ellinor Berglund	Resuscitation	2018	Quantitative descriptive	English	****
APP-based alert system	16	Caputo Maria Luce	Resuscitation	2017	Quantitative non-randomized	English	****
Staying Alive	38	Clement Derkenne	Academic Emergency Medicine	2020	Quantitative non-randomized	English	*****
FirstAED	12	Finn Lund Henriksen	Int. J. Networking and Virtual Organisations	2016	Quantitative non-randomized	English	****
	9	Laura Sarkisian	Resuscitation	2020	Quantitative non-randomized	English	*****
SimaGo	19	Steen M. Hansen	PLOS ONE	2015	Quantitative descriptive	English	***
Heartrunner	20	Linn Andelius	Journal of The American College of Cardiology	2020	Quantitative descriptive	English	****
Text message alert system	37	Sun Young Lee	Resuscitation	2019	Quantitative non-randomized trial	English	*****
MERIT 3	33	Tomas Barry	Resuscitation Plus	2021	Quantitative descriptive	English	*****
	32	Tomas Barry Resuscitation	2017	Quantitative descriptive	English	****	
Save A Victim Everywhere (SAVE)	21	K.B. Kern	Resuscitation	2019	Quantitative non-randomized	English	****
UnityPhilly	22	David G. Schwartz	EClinicalMedicine	2020	Quantitative non-randomized	English	*****
Life Guardians	13	Eli Jaffe	Prehospital and Disaster Medicine	2018	Quantitative descriptive	English	Not an empirical study
	31	Ziv Dadon	Disaster Medicine and Public Health Preparedness	2019	Quantitative descriptive	English	*****
Mobile-Rescuers	15	R. Stroop	Der Notarzt	2015	Quantitative descriptive	German	*****
MyResponder	14	Ng Wei Ming	Prehospital Emergency Care	2020	Quantitative descriptive	English	***

Table 1: Comparing the baseline characteristics of patients in intervention and control groups (continue)

System Name	Reference Number	Author(first)	Journal	Publication Year	Study Design[1]	Language	MMAT SCORE[2]
PulsePoint	11	Steven C. Brooks	Resuscitation	2016	Quantitative descriptive	English	****
	24	Tanner Smida Resuscitation	2022	Quantitative non-randomized	English	****	
	23	Jennifer Blackwood	Resuscitation	2020	Quantitative non-randomized	English	*****
AED-SOS	29	Toshihiro Hatakeyama	Simulation in Healthcare	2018	Quantitative randomized controlled trials	English	**
Smartwatch Application	39	Albert Del Pozo	BMC Public Health	2019	Quantitative descriptive	English	Not an empirical study
EVapp	40	Steven Vercammen	Cost Effectiveness and Resource Allocation	2020	Quantitative non-randomized	English	*****
TraumaLink	41	Jon Moussally	Global Health: Science and Practice	2022	Quantitative descriptive	English	*****

1: (Qualitative / Quantitative randomized controlled trials / Quantitative non-randomized / Quantitative descriptive /Mixed methods)
2: (*,**,***,****,*****, not an empirical study).

Table 2: General features of the systems

System Name	Launch countries	System startup	Type of technology (Platform)	Commercially available	Activity domain (Public, Residential or Both)	Time Limit
GoodSAM	UK, Australia, New Zealand, India, USA, Brazil, South Africa and in parts of Europe.	2015	App (multiple platforms (iOS, Android, Windows))	Yes	Both (mostly Residential)	NA
TM-alert system	The Netherlands	2008	Text message App (multiple platforms (iOS, Android))	NA	Both (mostly Residential)	24/7
prototype simulation CFR dispatch system	Japan	2013	App (multiple platforms (iOS, Android))	No	Residential	NA
Mobile Lifesaver Service (MLS)	Sweden	2010	Text message	Yes	Both (mostly Residential)	6/23
The lay-responder system (Mobile Lifesaver Service in App)	Sweden	2015	App (multiple platforms (iOS, Android))	Yes	Both (mostly Residential)	7/23
APP-based alert system	Switzerland	2014(App-based) 2006(SMS-based system)	App (multiple platforms (iOS, Android))	Yes	Both	24/7
Staying Alive	France	2017	App (multiple platforms (iOS, Android))	Yes	public	NA
FirstAED	Denmark	2012	App (iOS)	NA	Both	NA
SimaGo	Denmark	2012	App (multiple platforms (iOS, Android))	NA	Both (mostly Residential)	NA
Heartrunner	Denmark	2017	App (multiple platforms (iOS, Android))	Yes	Both (mostly Residential)	NA
Text message alert system	Korea	2015	Text message	No	Both	6/22
MERIT 3	Ireland	2015	Text message	No	Both	NA
Save A Victim Everywhere (SAVE)	USA	2018	Text message	NA	Residential	NA
UnityPhilly	USA	2019	App (multiple platforms (iOS, Android))	NA	Both	NA
Life Guardians	Israel	2014	App (multiple platforms (iOS, Android))	Yes	Public	NA
Mobile-Rescuers	Germany	2013	App (multiple platforms (iOS, Android))	Yes	Both	NA
MyResponder	Singapore	2015	App (multiple platforms (iOS, Android))	Yes	public	NA
PulsePoint	USA and Canada	2010	App (multiple platforms (iOS, Android))	Yes	public (In February 2017, PulsePoint introduced a professional version called Verified Responder that also alerts in residential settings)	24/7
AED-SOS	Japan	2015	App (multiple platforms (iOS, Android))	Yes	Both	9/18
Smartwatch Application	Spain	2019	App (Android)	NA	Both (mostly Residential)	NA
EVapp Belgium	2017	App (multiple platforms (iOS, Android))	Text message	Yes	Both	24/7
TraumaLink	Bangladesh	2014	Text message	Yes	Public (highways)	24/7

NA: not applicable; SMS: Short Message Service.

Table 3: Dispatcher features of the systems

System name	Notification origin	Activation criteria (Inclusion)	Deactivation criteria (Exclusion)	Sending notification[1]	Selection of notification recipient[2]	Assigning role for the rescuer
GoodSAM	Dispatch center/ Bystander	OHCA, medical emergencies include both adult and pediatric cases	Traumatic cases where cardiac arrest is confirmed or suspected	Automatically	Automatically	No
TM-alert system	Dispatch center	OHCA	No complete address known at the moment of dispatch, a non-cardiac cause, patient aged below eight years, ambulance or first responder nearby, or if an AED is already present.	Manually	Automatically (the procedure from the decision to alert TM responders to the completion of all TM-alerts is fully automatic and takes a few seconds)	Yes (assigns candidates to AED or CPR depending on distance)
prototype simulation CFR dispatch system	Dispatch center	OHCA		Manually	Manually (the dispatcher selects which community first responder is closest to the patient and who should respond)	No
Mobile Lifesaver Service (MLS)	Dispatch center	OHCA	Patients younger than 8 years old, a hazardous environment, and OHCA caused by drowning, trauma, intoxication, or suicide.	Manually	Automatically	No
The lay-responder system (Mobile Lifesaver Service in App)	Dispatch center	OHCA	Patients younger than eight years old, and traumatic or EMS-witnessed OHCAs	Manually	Automatically	Yes (according to their latest reported location, either to perform CPR or to retrieve AEDs)
APP-based alert system	Dispatch center	OHCA	Dangerous conditions of the intervention, ambulance arrival time estimated to be shorter than first responders	Manually	Automatically	No
Staying Alive	Dispatch center	OHCA		Manually	Manually	Yes
FirstAED	Dispatch center	OHCA or an emergency (disease, accident, cardiac arrest, traffic accident, hanging, birth, drowning, diver with decompression sickness).		Manually/ Automatic (FirstAED is activated by the nurses at the central dispatch center either on an iPad or by an automatic signal from the computer aided dispatch system)	Automatically	Yes, (No. 1 reaches the patient to give first aid/CPR; No. 2 brings the AED; and No. 3 is the onsite coordinator)
SimaGo	Dispatch center	OHCA	For patients younger than seven years old, the cause of the suspected OHCA being trauma/suicide or poisoning, when obvious signs of death are reported to the EMD, witnessed OHCA by ambulance services, or the home care provider being further than 10 km away from the OHCA site.	Manually	Automatically	Yes.(The first provider to arrive was instructed to focus on performing CPR; on the arrival of a second provider, an AED was to be applied)

Table 3: Dispatcher features of the systems

System name	Notification origin	Activation criteria (Inclusion)	Deactivation criteria (Exclusion)	Sending notification[1]	Selection of notification recipient[2]	Assigning role for the rescuer
Heartrunner	Dispatch center	OHCA	Cardiac arrests involving trauma, suicide, children younger than 8 years old, and those occurring in nursing homes or unsafe surroundings	Manually	Automatically	Yes (The first 4 responders who accept the alarm are guided via the smartphone application to fetch a nearby AED while the fifth responder is guided directly to the patient to perform CPR. This continues in blocks of 5 until the maximum of 20 responders is reached)
Text message alert system	Dispatch center	OHCA	Patients under 18 years old	Manually	Manually	No
MERIT 3	Dispatch center	OHCA		Manually	Automatically	No
Save A Victim Everywhere (SAVE)	Dispatch center	OHCA		Manually	Manually	Yes
UnityPhilly	The witnessing volunteer	Opioid overdose incidents		Manually	Automatically	No
Life Guardians	Dispatch center	Immediate life-threatening incidents such as respiratory or cardiac arrest, or major trauma or an MCI also those with chest pain, shortness of breath, or a possible stroke.		Manually	Automatically	No
Mobile-Rescuers	Dispatch center	OHCA	Unsafe environment	Manually	Automatically/ Manually (control center dispatcher can monitor the deployment alert and the deployment progress of the mobile rescuer and intervene at any time if necessary)	No
MyResponder	Dispatch center	OHCA and minor fire, major incident		Manually	Automatically	No
PulsePoint	Dispatch center	OHCA Other non-cardiac arrest events and medical emergencies: multi-casualty incidents, road collisions	Residential zone (expert verified responders), If dangerous scene conditions are identified during the 911 call (e.g., risk of violence, chemical, radiological, biological, or nuclear threats)	Automatically	Automatically	No
AED-SOS	Bystander	OHCA		Manually	Automatically	No
Smartwatch Application	Patient's smartwatch	OHCA In the absence of heart rate (> 3 s without a heartbeat) and when the smartwatch wearer falls down		Automatically	Automatically	No

Table 3: Dispatcher features of the systems

System name	Notification origin	Activation criteria (Inclusion)	Deactivation criteria (Exclusion)	Sending notification[1]	Selection of notification recipient[2]	Assigning role for the rescuer
EVapp	Dispatch center	OHCA		Automatically	Automatically	Yes (the three closest volunteers are mobilized towards the victim, and the fourth and fifth closest volunteers are sent to the victim via the closest public AED.
TraumaLink	TraumaLink call center	Although Volunteer First Responders training is focused on road traffic injuries, as the program matures in a community, also begins getting calls for other types of trauma, such as farming injuries, but these were not included in the current analysis.		Manually	Automatically	No
GoodSAM	300m In London 800m in East Midlands (although this radius can be modified according to local needs)	GPS	GPS	Yes	20s	3 In London 5 in East Midlands
TM-alert system	Maximum of 1000m	Registered addresses (can enter multiple addresses where responders are available at specific times per day of the week) (Using the zip code)	Text address (postcode)	Yes	NA	A maximum of 30
prototype simulation CFR dispatch system	3km (The radius can be set by the dispatcher)	GPS	Text address/ map link and GPS	Yes	NA	All (Within the circle who can respond)
Mobile Lifesaver Service (MLS)	500m	GPS	Text address (i.e. door codes)/map link and GPS	No	NA	All (in 500 m radius) (On average, 12 Responders)
The lay-responder system (Mobile Lifesaver Service in App)	Maximum of 1200 until a match was found of ten lay responders for CPR and 2400 m until a match was found of ten lay responders for AED	GPS	Map link and GPS	Yes	NA	A maximum of 20
APP-based alert system	No defined radius	GPS	Map link and GPS	Yes	NA	All
Staying Alive	500m	GPS	Map link and GPS	Yes	NA	All (in 500 m radius)
FirstAED	5km	GPS	GPS	Yes	NA	9
SimaGo	10km (by car)	GPS	GPS	No (Home care providers are equipped with an AED)	35seconds (if no response was received from an activated provider within 35 seconds, the call was automatically registered as declined)	2 (if they were unable to interrupt their ongoing task, in which case the third-nearest provider was activated, and so forth)

Table 3: Dispatcher features of the systems

System name	Notification origin	Activation criteria (Inclusion)	Deactivation criteria (Exclusion)	Sending notification[1]	Selection of notification recipient[2]	Assigning role for the rescuer
Heartrunner	1.8km (maximum 15 min with a default speed of 2m/s)	GPS	GPS	Yes	NA	Up to 20
Text message alert system	No defined radius	Registered fixed address (workplace address, and home address)	Text address	Yes	NA	All
MERIT 3	10km (by car)		Text address (postcode)	No (GPs are equipped with an AED)	NA	All
Save A Victim Everywhere (SAVE)	No defined radius	NA	Text address	Yes	NA	All
UnityPhilly	Within a 15-minute estimated time of arrival to the overdose site, calculated dynamically based on the participants' declared transport mode (foot, car, etc.)	GPS	GPS	Yes (nearby pharmacy map for nasal Naloxone)	The system sent alerts to additional volunteers if an alerted volunteer did not acknowledge within 2min	4
Life Guardians	No defined radius	GPS	Text address/ map link and GPS	No		All (within 5 mins walking) (If there is an MCI, then the radius of responders can be increased.)
Mobile-Rescuers	300m by foot estimating the arrival time of the rescuer by GPS (to 8 min)	GPS	Map link and GPS	No		2
MyResponder	400m (1500 m for listed taxi drivers with AED)	GPS	Map link and GPS	Yes		All
PulsePoint	400m (This radius can be adjusted by the hosting public safety agency) (on October 1, 2018, to activate more Verified Responders for suspected OHCA, expanded their notification radius to a half mile) (800m)	GPS	Text address/ map link and GPS	Yes (Verified responders are often equipped with an AED)	NA (until professional responders had already arrived on the scene)	All (within a defined activation radius)
AED-SOS	200m	GPS	GPS	Yes	NA	2 (in this simulation)
Smartwatch Application	300m (if no member was found in the closer radius, the radius is increased to 600m)	GPS	Map link and GPS	Yes	NA	All (in the defined radius)
EVapp	500m (if the desired amount of responses (>3) within 500 m is not met, the radius is systematically increased to a maximum of 1500m)	GPS (if no volunteer is found by GPS, their home and/or work addresses can be used for activation too)	Map link and GPS	Yes	NA	5
TraumaLink	Catchment areas are divided into operational zones roughly 1–2 km in length	Based on where volunteers live and/or work (in every operational zone)	GPS/ text address (local name of cites)	Yes	NA	NA (dispatching an appropriate number of volunteer first responders prioritized by their proximity to the crash scene)

1: Activation of system: automatically with emergency medical services (EMS), or manually by a dispatcher; 2: Sending alert by computer automatically according to the default settings, or manually by dispatcher.
OHCA: Out of Hospital Cardiac Arrest; AED: Automated External Defibrillator; CPR: cardiopulmonary resuscitation; EMD: Emergency Medical Dispatch; MCI: Mass Casualty Incident.

Table 4: Responder features of the systems

System name	Rescuer (lay or professional)	Rescuer recruitment	Rescuer training requirement	Ability to set the status (i.e., available or not, on the route, on the scene)	Ability to accept or decline the mission	Ability to contact the dispatch center during mission	Ability to track ambulance or other rescuers	Ability to send report after mission	Equipment
GoodSAM	Health care professionals (e.g., doctors, nurses, paramedics, emergency medical technician) or lay rescuers (CPR-trained)	NA	Yes	Yes	Yes (there are 3 options, accepted, rejected, or not seen for responder)	Yes (live video)	Yes (other rescuers are shown in the app)	Yes (all responders are encouraged to complete a report form after being alerted)	AED (Health care professionals that routinely carry additional life-saving equipment may use it if appropriate)
TM-alert system	Lay rescuers (not required to have medical expertise)	Various local advertisements and campaigns	Yes	No	Yes	No	No	No	AED
prototype simulation CFR dispatch system	Off-duty health care providers (firefighters)	NA	No	Yes (“dispatch possible”, “dispatch impossible”, “dispatched”, “arrived”)	Yes	Yes	No	No	AED (as required)
Mobile Lifesaver Service (MLS)	Lay rescuers (CPR-trained)	Through mass media campaigns including advertisements in newspapers and on websites	Yes	No	Yes	No	No	No	No equipment
The lay-responder system (Mobile Lifesaver Service in App)	Lay rescuers (CPR-trained)	Through e-mails, advertisements in social media, newspapers, and CPR-training companies	Yes	No	Yes	No	No	No	AED
APP-based alert system	Mostly lay rescuers but can include off-duty health care providers (i.e., physicians, nurses, CPR course graduates)	NA	Yes	Yes (“I am available”)	Yes	No	No	No	AED

Table 4: Responder features of the systems

System name	Rescuer (lay or professional)	Rescuer recruitment	Rescuer training requirement	Ability to set the status (i.e., available or not, on the route, on the scene)	Ability to accept or decline the mission	Ability to contact the dispatch center during mission	Ability to track ambulance or other rescuers	Ability to send report after mission	Equipment
Staying Alive	Lay rescuers (CPR-trained)	Local press and on social networks	Yes	Yes ("available," "dispatched," "on the way")	Yes	Yes (Phone call)	No	No	AED
FirstAED	Lay rescuers (18 years of age or older)	Adverts in the local newspaper, posters in the town, and streamers on the cars	Yes	No	Yes	No	No	Yes (When the call-out is completed, the first responders have the opportunity to fill in a case report on their smartphones)	AED
SimaGo	Home care providers	By the municipality	Yes	No	Yes	No	No	Yes (The home care providers also completed a case file for each dispatch)	AED, a kit containing pads, scissors, gloves, and cardiac-arrest action cards
Heartrunner	Lay rescuers (26.0% were health care professionals.) (18 years of age or older)	Social media, television commercials, and newspaper advertisements	No (but 98.6% reported having received CPR training before registration)	No	Yes	No	No	Yes (All responders who accept the alarm receive a questionnaire 90 minutes after the alarm)	AED
Text message alert system	Lay rescuers (CPR-trained)	NA	Yes	No	Yes	No	No	No	AED
MERIT 3	GPs and a small number of other doctors	NA	Yes	Yes	Yes	Yes	No	Yes (GPs individually provide reports on text alerts received)	AED, basic life support and personal protective equipment (including basic airway management equipment, intravenous access equipment, gloves, eye protection and high visibility vest)

Table 4: Responder features of the systems

System name	Rescuer (lay or professional)	Rescuer recruitment	Rescuer training requirement	Ability to set the status (i.e., available or not, on the route, on the scene)	Ability to accept or decline the mission	Ability to contact the dispatch center during mission	Ability to track ambulance or other rescuers	Ability to send report after mission	Equipment
Save A Victim Everywhere (SAVE)	Local Lay rescuers (located in Green Valley, Arizona) (55 years of age or older)	NA	Yes	No	Yes	No	No	No	AED
UnityPhilly	Lay rescuers (18 years of age or older)	NA	Yes	Yes (“En-route”, “Can’t go”)	Yes	Yes (chat and live video)	Yes	No	A kit containing two doses of intranasal naloxone (2 £ 4 mg)
Life Guardians	Health care professionals (physicians, nurses, prehospital care providers) or lay rescuers (CPR-trained)	Recruitment advertisements	Yes	Yes ("On-scene”)	Yes	Yes (Phone call)	Yes	No	A kit that is 32x32x12 cm in size. For physicians, nurses, and paramedics, including a bag-valve-mask device, oropharyngeal airways, tourniquets, and bandages. For EMTs, the kit contains the same equipment minus the airway devices
Mobile-Rescuers	Off-duty health care providers (physicians, paramedics, nurses, or firemen) (not lay rescuers)	Media (radio/tv/newspaper) and online app (Facebook and web page)	Yes	Yes	Yes	Yes (Phone call)	No	Yes	Mask and glove
MyResponder	Lay rescuers With relevant skills such as CPR	NA	No	Yes. (“arrived”)	Yes	Yes	No (but the app shows the number of rescuers at the scene)	Yes (Responders can also submit feedback, and send photos and videos to the dispatch center via the app)	AED
PulsePoint	Lay rescuers and health care providers (e.g., paramedics, emergency medical technicians, firefighters, other health care providers)	Messaging individuals with CPR training by resources from the PulsePoint Foundation. Local media and fire/EMS agencies	No		Yes	Yes (phone call)	No	Yes (electronic survey)	AED

Table 4: Responder features of the systems

System name	Rescuer (lay or professional)	Rescuer recruitment	Rescuer training requirement	Ability to set the status (i.e., available or not, on the route, on the scene)	Ability to accept or decline the mission	Ability to contact the dispatch center during mission	Ability to track ambulance or other rescuers	Ability to send report after mission	Equipment
AED-SOS	Lay rescuers (18 years of age or older)	Local CPR training networks, billboards, advertisements, and web site	No	No	Yes	No	No	No	AED
Smartwatch Application	Population groups that are routinely in contact with people at risk of OHCA (police, firemen, teaching staff, health workers, shopkeepers, pharmacists, university students, gym instructors and others), as well as relatives of people with heart disease. In the case of elderly people living alone, neighbors and caregivers	Contact by phone	Yes	No	Yes	No	No	No	AED
EVapp	Health care professionals or Lay rescuers (CPR-trained)	Through interaction with professional organizations	Yes	No	Yes	No	No	Yes (after each intervention, the volunteers receive a feedback form)	AED
TraumaLink	Local Lay rescuers, most of whom live and/or work near the highway (18 years of age or older) (there are no minimum literacy or educational requirements)	Organizing multiple events to raise awareness about road traffic injuries, and foster discussions. Also working with local religious and civic leaders, as well as the family members of those interested in volunteering, advertising services and hotline numbers through community engagement events and various types of local media.	Yes	No	Yes	Yes (phone call)	No	Yes (call center operators follow up by phone with volunteers)	First aid kits

CPR: cardiopulmonary resuscitation; NA: not applicable; AED: Automated External Defibrillator; GP: General Practitioner; EMT: Emergency Medical Technician; EMS: Emergency Medical Services.

Table 5: Other features of the systems

System name	Legal issues	Insurance coverage	Users profits	Further
GoodSAM	*In the UK, there is no legal obligation for a GoodSAM responder to accept an alert. *GoodSAM has a detailed Data Protection policy.	No	No	*GoodSam can send an alert (as an audible siren). *The alert will remain active on the phone for up to 15 min. *The screen also displays a brief descriptor of the patient (e.g., 'cardiac arrest—not breathing at all').
TM-alert system	NA	No	No	
prototype simulation CFR dispatch system	NA	No	No	If desired, the dispatcher can also select responders who are outside the pre-set distance from the patient.
Mobile Lifesaver Service (MLS)	*All Responders agree upon registration to not utter any details about the suspected cardiac arrest alarms that could lead to the identification of patients. *The Responders have to agree to be geographically positioned before receiving alarms of suspected OHCAs. *The Responders can at any time erase their user information on the project website. *Specific personal information such as the full name of the patient or birth date is not sent to the Responders.	No	No	Since the geographical position of all emergency calls in Sweden can automatically be determined, it is easy to find the incident's location.
The lay-responder system (Mobile Lifesaver Service in App)	NA	No	No	
APP-based alert system	NA	No	No	Due to Swiss federal and cantonal privacy law, the exact location or address of the victim cannot be transmitted as a text message. Therefore, contact between the first responder and the EMS dispatcher is needed.
Staying Alive	NA	No	No	
FirstAED	NA	No	No	
SimaGo	The home care providers are instructed to strictly observe speed limits and other traffic regulations when alerted.	No	No	Weekly test calls and monthly dispatches maintained acquired skills.
Heartrunner	NA	No	No	
Text message alert system	NA	No	No	*The volunteer registration remained valid for two years. *In Korea, real-time location tracking is prohibited due to privacy.
MERIT 3	NA	Yes	No	
Save A Victim Everywhere (SAVE)	NA	No	No	
UnityPhilly	Responders in Pennsylvania are afforded certain legal protections through the 'Good Samaritan' provision of the Act.	No	No	The App can review salient overdose information including instructions for recognizing overdose, administering naloxone, and rescue breathing.
Life Guardians	Israel, in 1998, enacted the law known as "Do not stand idly by your neighbor" to assist a person in danger or at the very least call for help.	Yes	No	

Table 5: Other features of the systems

System name	Legal issues	Insurance coverage	Users profits	Further
Mobile-Rescuers	*The location data of the participants cannot be viewed by the control center dispatchers outside of an operation. *In the declaration of consent, the mobile rescuers give their consent to the storage of the current location data.	Yes	No	*A mobile rescuer is promptly notified when he arrives within eight minutes of the alert. *When the responder arrives at the scene of an incident, he can legitimize himself using a digital first-aider ID card created for this incident (Digital, mission-related first aid card).
MyResponder	There is no legal liability when responders are unable to accept or if they cause an injury to the victim, such as a rib fracture during the administration of CPR.	No	No	Those below 18 years old are required to seek parental consent to use the app.
PulsePoint	Program participation required that the employer organization contractually offer compensation and liability protection to professional responders in the event of an off-duty response.	Yes (verified responders)	No	*Once professional responders arrive on the scene, notifications delivered via the PulsePoint Respond application are removed. *Upon downloading the application, users are reminded to respond safely and respectfully. *Some agencies opted for a special agency-issued Verified Responder badge to be carried while off-duty, but there were no standardized identification requirements (e.g. clothing) for off-duty response. *In the first version, the notification would not override the phones sleep or silence setting, but all volunteer participants were provided the option to install a silence override when this software upgrade became available in December 2018.
AED-SOS	NA	No	No	
Smartwatch Application	NA	No	No	
EVapp	NA	Yes	No	
TraumaLink	NA	No	No	TraumaLink fully reimburses Responders and area coordinators for any local travel expenses incurred while responding to crashes and transporting patients.

NA: not applicable; OHCA: Out of Hospital Cardiac Arrest; EMS: Emergency Medical Services