Emergency Phone Call Alternatives: a Review

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***Abstract*— Emergency calls usually made over a telephone line may have limitations, such as: speech or hearing difficulties of the speaker; impossible verbal communication due to the circumstance (aggression, threat, etc.); difficulty of the call to be established due to location or lack of signal. To overcome these limitations, alternatives must be found. The alternatives have several advantages over the emergency telephone line since they use newer technology and have the advantage that they can adapt to the various circumstances in which the emergency call is made, as well as to the difficulties of the callers. With emergency phone call alternatives, it is possible to address issues such as: sending the exact and up-to-date location of the emergency call as well as sending all necessary information, avoiding the time-consuming questions that telephone operators have to ask, which is crucial for responding to the emergency; carrying out an emergency call discreetly; facilitating the call for help for people with communication difficulties or when verbal communication is not possible; sending information via audio, video, and text. These alternatives have the disadvantage of depending on the use of the Internet for their operation, which with technological advances, tends to be a mitigated problem. A systematic review has been conducted based on Preferred Reporting Items for Systematic Re-views and Meta-Analyses (PRISMA) methodology and the studies address some consistent evidence about emergency telephone line alternatives and how these are an asset to emergency requests and responses, creating knowledge for the development of a digital solution.**

Keywords- Emergency; Application; Mobile; Help; Telephone Line.

I. Introduction

Generally, requests for help are made only using an emergency telephone line. Because it is a telephone call, it is necessary to have a verbal communication between the caller and the operator, which sometimes becomes a problem due to several factors, such as the circumstances or weaknesses of the caller [1]-[3].

Examples of difficulties in the call for help are: during a robbery, when the robber is nearby; a pursuit; domestic violence or direct aggression; a person with communication difficulties; or others. In these cases, the possibility to verbally communicate with the operator is limited, making the call for help difficult or even impossible. What often happens in these circumstances in a call to the emergency telephone line is that nobody speaks, and the operator is unable to assess the situation and its location, two of the most important pieces of information to send the appropriate help. Another example where the emergency telephone line cannot be used is when dealing with deaf and/or people with disabilities, as they are not able to communicate verbally with the operator, thus always depending on others, if it is necessary to make a call for help. An application where users can make distress calls in situations where verbal communication is not possible or when the conditions for indicating the location are not met, for example, would be the most appropriate solution.

The approach to supporting the development of an efficient solution for the calls for help in these contexts is to carry out a systematic review of scientific studies where the state of the art can be assessed regarding aspects such as: forms of communication in the context of the call for help; information sent; mechanisms and/or computer solutions used and their advantages over the emergency telephone line used in order to support the development of a user-centric system. However, this approach also has some limitations. The literature search was performed only in three scientific databases. This decision may have influenced the number of relevant studies obtained. The use of other databases could possibly have increased the number of studies analyzed and contributed to improving the general analysis, as well as the search strategy, which had restricted the number of non-relevant studies (studies published many years ago, very general studies, studies that do not focus on the research objectives, or studies not written in English). However, these restrictions did not have a significant effect on the discussion and conclusions.

This paper is organized as follows. Section 2 presents the details of the methodology of the systematic literature review. Section 3 describes the strengths and limitations of this work. Finally, Section 4 presents the conclusions and directions for future work.

II. Methodology

The objective of this work is to analyze scientific articles that contain supporting information for the development of an emergency system as an alternative to the telephone line. The review is reported according to the PRISMA [4].

A. *Research questions*

Our work aims to address the following research questions.

Question_1: What are the alternatives to the emergency line/other solutions for emergency calls?
Question_2: What mechanisms/computer solutions are necessary or can be used to create an alternative system for emergency calls?
Question_3: What information can/should be transmitted in emergency calls?
Question_4: What are the advantages of alternatives to the emergency phone line?

B. *Inclusion criteria*

The literature studies are selected according to the following criteria.
Criterion_1: Studies between 2016 and 2021.
Criterion_2: Studies written in English.
Criterion_3: Studies in which the full text is available.
Criterion_4: Systems that respond to help requests.
Criterion_5: Systems that use mobile applications, desktop applications and different telephone line technologies for emergency calls.

C. *Search Strategy*

In this the research, the databases *IEEEXplore, ACM Digital and ScienceDirect* were used to identify the articles. The set of search terms were: "Emergency Application" AND "Mobile", "Emergency System" AND "Mobile". The research was conducted between November and December 2021.

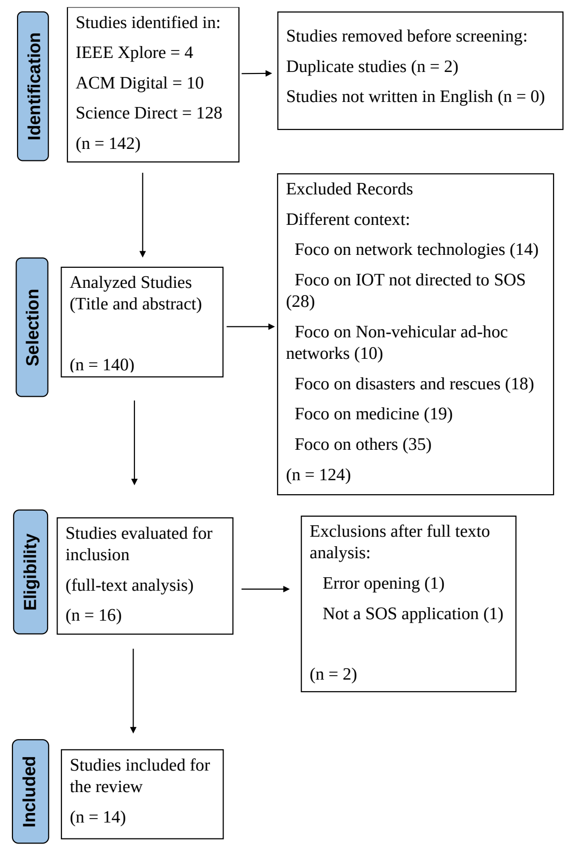

Figure 1. Flow diagram for new systematic reviews (adapted from [4])

III. RESULTS

As presented in Figure 1, after the research was performed and criteria 1 was applied, 142 scientific studies were found, 4 from the *IEEEXplore* database, 10 from the *ACM Digital database* and 128 from *ScienceDirect*. Applying criteria 2, as well as the removal of duplicates, resulted in the exclusion of 2 studies. Thus, 140 studies were analyzed based on the title and the abstract, 124 being excluded based on criteria 4 and 5. The full text analysis of the 16 resulting studies was performed and criteria 3, 4 and 5 were applied. The remaining 14 studies were included for review. Data were extracted from all studies identified using a predefined format. Data extracted included: study; year of publication; alternatives to the emergency line; information transmitted; advantages. Table I identifies the extracted data of the included studies. The characteristics of the included studies have been summarized in the following text.

In [5], the authors developed a mobile application that allows making distress calls without looking at the screen phone. The request is made by holding rhythm patterns, such as taps on the screen with the phone, that can be in the pocket, and thus a distress call can be made without others noticing that it has been made. The application allows three features: send an SOS request to a person elsewhere, audio or video recording, and an SOS function that alerts people near you to get help.

TABLE I. EXTRACTED DATA.

Article	Year Publication	Alternatives to the emergency line	Information transmitted	Advantages
An Emergency Application for Smartphones Based on Rhythm Pattern Recognition [5]	2016	Mobile app enabled by touch patterns on your smartphone	Location, audio, video, text	Sending discreet and fast distress calls
A cloud-based architecture for emergency management and first responders' localization in smart city environments [6]	2016	IOT e *cloud*	Location	Easier to locate
Information visualization for emergency management: A systematic mapping study [7]	2016	Computer system	Text	Improves emergency management
Dynamic LTE resource reservation for critical M2M deployments [8]	2017	LTE mobile networks	Text	Receiving data without human intervention

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Article	Year Publication	Alternatives to the emergency line	Information transmitted	Advantages
Bangladesh Emergency Services: A Mobile Application to Provide 911-Like Service in Bangladesh [9]	2018	Mobile app	List with emergency services	Allows to consult the available emergency services, their location, and contacts
OpenAlerts: A Software System to Evaluate Smart Emergency Alerts and Notifications [10]	2018	Mobile app	Text, images, location	Allows to inform users that there is an occurrence nearby
Towards a next generation 112 testbed: The EMYNOS ESInet [11]	2018	Emergency calls from the internet	Audio, video, and instant messaging	Allows to make emergency calls over the internet
Modern Mobile Emergency Applications: Fact or Fiction? [12]	2019	Mobile app	Location	Easier to locate help request
Client-based Total Conversation Solution to Support People with Hearing Impairment in Medical Emergency [13]	2020	Mobile application for video-conference	Audio, video	Distress calls from people with hearing impairments
Design and implementation of a Vision Stick with Outdoor/Indoor Guiding Systems and Smart Detection and Emergency Features [14]	2020	Mobile app connected to a cane	Location, text, audio	Guide individuals with visual impairments, and call for help through the cane
Highly-efficient fog-based deep learning AAL fall detection system [15]	2020	IOT and mobile app	Text, location	Allows to alert a care giver that elderly person has fallen
Why do people want to use location-based application for emergency situations? The extension of UTAUT perspectives [16]	2021	Mobile app	Text	Higher performance, more reliable service
Increasing disaster victim survival rate: SaveMyLife Mobile Application development [17]	2021	Mobile app	Location, text,	Allows to visualize disasters on a map in real time and call for help
Crowdsourcing to save lives: A scoping review of bystander alert technologies for out-of-hospital cardiac arrest [18]	2021	Mobile app	Location, text	Faster assistance in the event of a heart attack

In [6], the authors present an emergency management service that uses IoT services and hybrid cloud architecture, the location, and orientation of first responders in emergencies. The service also provides functions for obtaining, storing, and processing various information that is extremely useful for decision-making in emergency response situations. One is the deployment of devices in reference points of an occurrence. Using the rescuers' mobile devices, the system can draw an approximate map of the location, which can be used to identify the space in which the rescuer is moving, supporting movements in unknown rescue locations.

In [7], the authors did a systematic analysis of how researchers use information visualization systems for emergency management. This analysis had important conclusions to be used by researchers, who can then analyze and develop new emergency management systems. The main conclusion was that: map-based visualization is the most used visual tool; emergency response is the phase of emergency management is the most dynamic phase because the tasks performed in this phase are sensitive and executed quickly and the one with the greatest potential to receive technological innovations; databases are the most used data source; and real data, are used more than simulated data. The results of the study thus provide insight into the area studies what helps in the development of technologies to help in the management phases of an emergency. Moreover, knowing the current trends, for example the forms of visualization and interaction in emergency management can be studied and verify if they are the best for the scenarios where they are used. As for the gaps found, such as the authors' proposing not very wide-ranging approaches to emergency management, these are important to help researchers improve them.

The study in [8] presents Machine to Machine (M2M) communications as a technology of high importance in distress calls. Through devices in areas where help is needed, data can be exchanged to respond to the rescue, but to have this sending and receiving of data in M2M communications, they mainly use mobile communications standards where Long-Term Evolution (LTE) is the most used. To use these technologies in emergency environments, it is necessary to ensure that communications are reliable and uninterrupted. So, in this study some techniques (probabilistic resource reservation and prediction-based resource reservation) are needed to dynamically allocate part of the LTE resources for emergencies to ensure that there is no competition in the use of communication resources by the rest of the network and that there is an isolated network part to ensure secure communications.

In the study from [9], the authors describe a mobile emergency application that provides emergency line-like services (991) in Bangladesh. The system provides a dynamic, up-to-date list of all emergency services in Bangladesh. Using Google Maps, users can scan for the location of nearby emergency services, as well as the directions to them. Calls can be relaunched without having to fix the numbers, as these are available in the app.

In [10], the authors present a system for testing emergency notifications. The system allows the creation and testing of sophisticated emergency alert notifications, which can contain various types of information, such as a map with the affected area and the exact location of the user or text informing of an event. This is useful, for example, to notify users that an emergency is occurring in a nearby area.

In [11], the EMYNOS - nExt generation eMergencY commuNicatiOnS project is described, which is an Internet Protocol (IP) address-based platform for emergency services, and the project is funded by the European Commission. This study presents the introduction of IP in emergency systems in Europe, thus will be possible emergency calls, which include audio, video, and instant messaging. This solution is based on the Emergency Services Internet Protocol Network, which is an internal IP-based network and can be shared by all Public Safety Answering Points. With the development of the platform, it is now possible for citizens to make emergency calls from the internet.

The authors of [12] have conducted a study to compare the current emergency applications and emergency phone lines. They described some difficulties and problems of emergency calls. One of the main difficulties identified was a call location and reporting it so a mobile application can solve that problem. They also mention that emergency applications face several problems and some of them can be solved with 5G technology. Finally, they present a developed application, when 112 was dialing a trigger was activated that using the Pan-European Mobile Emergency Application architecture allows sending an emergency message containing the precise location and citizen information. Even if the user is in a different country, the application sends the information to the correct emergency response point.

The authors of [13] present a system that allows people with hearing impairment to request help. The system allows a specialist in communication with people with these limitations, as an intermediary of the conversation having audio and video support to communicate with the person who makes the request, but only provides audio to the emergency center person. This system helps both the person making the request and the person responding to it, to communicate with each other using a specialist in communication with people with hearing difficulties.

In [14], a walking stick is described for visually impaired individuals. This cane allows guiding the individual to defined locations through voice commands and connects to a mobile application using google maps. The walking stick also has a system to monitor obstacles around the individual and provides information on how to avoid them. In addition, it also has an SOS button that, through a Global System for Mobile (GSM) module, sends an SMS to family members or friends with the exact location of the individual if there is no response from any of them, the system calls the authorities through the GSM module.

In [15], a system for fall detection especially suitable for the elderly, is presented. This system is based on Deep Learning and IoT, where there is no button to be pressed in case of a fall but a set of sensors on the users' clothes. When a fall is detected, an alert is sent to the elderly caregiver's cell phone through the application associated with the sensors.

In [16], the authors studied the intentions of the population to use a mobile emergency app in developing countries such as Indonesia. An existing emergency app was used to distribute questionnaires and allowed to analyze some determinants in the use of the app for calling for help, such as performance, trust in the service, social influence, fear of criminal activities, and privacy issues. This study concluded that trust has the most significant impact on the population's intention to use an emergency app. It is since the population believes, in the ability of the app to send the distress message quickly, accurately, and reliably. The concern about personal data collection is the factor that most negatively influences the population to use an emergency app.

The authors of [17] present an Indonesian emergency mobile application for disasters, with a special focus on earthquakes. Disasters in real-time appear in map. For example, in the case of earthquakes, the location and magnitude are indicated. The application has an SOS button that can be pressed by users to call for help. After the user presses the button, the request and its location are sent to the rescuers. The rescuer has a map with the locations of the various distress calls then the system helps to prioritize the calls based on four variables: age, distance to the point of safety, health status, and regional disaster risk.

The authors in [18], conducted a study on applications and systems for alerting of a cardiac arrest. The systems focused on issuing an alert, sending a notification to nearby devices, so that someone who is nearby, and has first aid training, can perform resuscitation maneuvers until medical help arrives on the scene. Some of the systems studied also alerted those who did not have first aid training because even if they did not have such training, they could follow some instructions in the applications or by calling for help. In this study, they tried to identify and characterize these systems, where most are mobile applications that send push notifications to people within a certain radius of the occurrence and through GPS directions guide them to the occurrence. The authors also try to summarize the literature and look for gaps in it, identifying, for example, difficulties in recruiting people to use these applications, because there are still concerns about security and responsibility when responding to these alerts. They also identify the existence of a problem in many countries, related to the guarantee of protection to the citizen volunteers who respond to the alerts, namely in issues related to injuries, or even death resulting from the rescue provided.

IV. Discussion

Based on the results presented in Figure 2, the articles analysed were published between 2016 and March 2021, three articles in 2021 (21.4%), three articles in 2020 (7.1%), one article in 2019 (7.1%), three articles in 2018 (21.4%), one article in 2017 (7.1%), three articles in 2016 (21.4%). Figure 2 shows the number of analyzed articles per year.

Regarding alternatives to the emergency line, in the analyzed studies, mobile applications are the most used for developing alternatives, as illustrated in Figure 3.

Regarding the information transmitted in the alternative systems to the emergency line, the one that stands out the most is the "text" where 11 studies use it for information communication. Next, "location information" is the most used and the least used, nonetheless, are "images". This analysis is set out in in the graph in Figure 4.

According to the analysis of the 14 studies, it can be concluded that new ways to make emergency requests and new systems to respond to emergencies have been developed. Although there are still several difficulties and setbacks in these new systems, more technological, and that use the internet instead of the telephone line, it is expected that, with the evolution of mobile networks, namely the appearance of 5G, some of these difficulties will be solved. It is also possible to conclude that several emergency systems have been developed focused on responding to specific problems and difficulties that exist in the current emergency phone line, for example, the difficulty in making requests for help by people with verbal or auditory communication difficulties, with visual difficulties, in situations where verbal communication is not possible or in situations where it is necessary to make the request without anyone else noticing that it was made. There is also a search for computer solutions at the technical level, for these systems where there is a focus on the use of the internet of things and cloud computing.

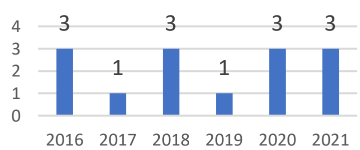

Figure 2. Studies per year

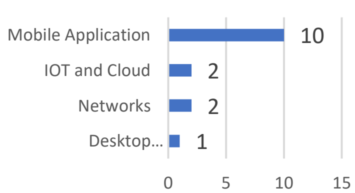

Figure 3. Emergency phone line alternatives

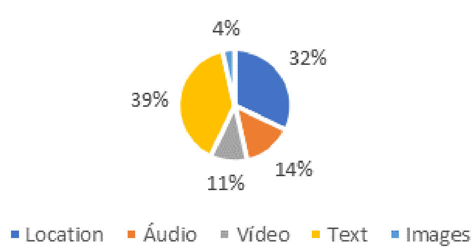

Figure 4. Information transmitted

Thus, from the fourteen articles analyzed, the main conclusions were:

(Q1) What are the alternatives to the emergency line/other solutions for emergency calls?

Mobile applications and computer systems are a great alternative to the current emergency line. These solutions have the advantage of allowing many features, such as: sending the exact and updated location in the distress call; sending distress calls discreetly; sending distress calls facilitated by people with disabilities; and sending information through audio, video, and text - which phone calls do not allow, becoming an asset for the calls and consequent response to them, [5]-[18].

(Q2) What mechanisms/computer solutions are necessary or can be used to create an alternative system for emergency calls?

With the evolution of technology, there is a focus on mobile devices use, the internet of things, and cloud computing systems to create alternative systems for distress calls, [5][6][11]-[13][15][17].

(Q3) What information can/should be transmitted in emergency calls?

With today's technology it is possible to transmit any information needed in a distress call, e.g. audio, video, images, exact location, text, etc., [5][11]-[15][17][18].

(Q4) What are the advantages of alternatives to the emergency phone line?

These new alternatives to the emergency telephone line, by using newer technologies, have the advantage that they can adapt to the various circumstances in which the emergency call is made and to the difficulties of the person making it. Thus, new functionalities are possible, such as

- sending the exact and up-to-date location of the distress call, which avoids the many questions that must be asked over the emergency phone line, which takes essential time for the rescue.
- sending distress calls discreetly, which in certain circumstances is critical, as verbal communication may not be possible or help may be needed without anyone noticing.
- the sending of distress calls made easy for people with disabilities, which prevents them from communicating.
- sending information via audio, video, and text.

In other words, new ways are provided to make requests for help with greater accuracy, detail and speed that were not possible with the emergency telephone line possible [5]-[18].

V. Conclusion

With the performed analysis it is possible to conclude that several studies have been conducted to find alternative and viable solutions to distress calls. There are some systems developed however each one has its characteristics and focuses on a particular context.

New technologies have also given an impulse to the development of these new systems because they allow the

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improvement of the current emergency systems and make them even faster, more accurate, and more accessible to everyone. This presents a benefit to improving emergency response and saving lives. The need to connect to the internet is the major obstacle to these new alternatives, but 5G tends to tackle the problem.

There is a need for systems that allow the communication of distress messages discretely, as well as tracking the route or location of the victim, but no information was found on systems with these characteristics, which shows a research opportunity. Based on the analysis made, the lack of information and support systems for victims would be beneficial to analyze and develop a system that solves this gap for future work.

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