

Inclusive access to emergency services: an action research project focused on hearing-impaired citizens

Vaso Constantinou¹  · Andri Ioannou¹ · Paloma Diaz²

Published online: 30 November 2016
© Springer-Verlag Berlin Heidelberg 2016

Abstract In case of emergency, hearing-impaired people are not always able to access emergency services, and hence, they do not have equal access to social support and infrastructure. In this work, we describe an action research study that undertakes the development and evaluation of a system aiming to meet the communication needs of hearing-impaired citizens in cases of emergency. The system consists of (1) a mobile application that records and sends the details of an emergency event and (2) a central management system that handles these calls from the operation center at the emergency services. The system was completed in four cycles of design, development and evaluation with the involvement of 74 hearing-impaired users and three officers from the Cyprus Police (Emergency Response Unit). Results demonstrated how the system can provide easy and direct access to emergency services, without the need of any intermediate, enabling the inclusion of these citizens in a critical process such as the response to an emergency.

Keywords Technology for hearing-impaired people · Inclusive citizen participation · Inclusive design · Action research · Emergency services

1 Introduction

In the European Union, 9% of the total population, that is 44 million people, are deaf or hard of hearing [7]. In Cyprus, where this action research was conducted, the number of deaf or hard of hearing people is currently approximated at 1000, according to official data from the Ministry of Labor Welfare and Social Insurance. The rights of people with disabilities are registered internationally by the UN Convention on the Rights of Persons with Disabilities and locally by the constitution and laws of the Republic of Cyprus [16]. The existing legal framework requires equal treatment including the right for “*access to information and communication with special means, where necessary, especially for certain groups of people with sensory disabilities*” [16]. Unequal treatment is determined as the impossible or unreasonably difficult access to services and the failure to implement changes, such as the use of specific tools that would facilitate access to services for persons with disabilities. However, although the legislation guarantees the rights of people with disabilities, in practice the implementation of accessibility for all is limited, with an emphasis on physical access. In this work, we emphasize that the concept of access is not limited to physical access, but should also include access to services that rightfully belong to all citizens including those with disabilities.

A few studies have focused on the obstacles faced by hearing-impaired people when contacting emergency services. These studies have shown that they have significantly less recorded access to primary care and emergency services [15], which is largely due to infrastructure deficiencies [11]. According to the European Commission, the majority of disabled people have no access to the EU emergency number 112, mainly due to weak infrastructure,

✉ Vaso Constantinou
va.constantinou@edu.cut.ac.cy

Andri Ioannou
andri.i.ioannou@cut.ac.cy

Paloma Diaz
pdp@inf.uc3m.es

¹ Cyprus Interaction Lab, Cyprus University of Technology, 30 Archbishop Kyprianou Str., 3036 Lemesos, Cyprus

² DEI Lab, Universidad Carlos III de Madrid, Avda de la Universidad 30, 28911 Leganes, Madrid, Spain

equipment and procedures. Seven countries have implemented infrastructures for 112 in order to be accessible by people with hearing disabilities [7]. The solutions implemented to date vary across countries. In some countries, specialized text phones are used and communication is made by exchanging messages, or in some cases, text is translated into voice through a relay service. Another solution implemented in France involves communication by sending a fax using preprinted sheets [7]. Some other solutions allow the exchange of SMS with the emergency services, but have the disadvantage of a possible delay in messaging as supported by Chiu et al. [3] and Meng et al. [10]. Considering that hearing-impaired citizens are not always very proficient at using the written language and therefore their ability to use SMS as a communication tool in emergency situations is limited [7], some EU countries have used communication services with predefined SMS messages containing the event location using GPS [7]. As another option, specialized video relay services (video relay service/video relay interpreting) support the communication between a hearing-impaired person and normal hearing person through an intermediate operator who translates from and to the sign language.

This action research study undertakes the development and evaluation of a system aiming to meet the communication needs of hearing-impaired citizens in cases of emergency. The system consists of (1) a mobile application which records and sends the details of an emergency event and (2) a central management system that handles these calls from the end of the emergency services. The implementation was completed in four cycles of design, development and evaluation. The rest of the manuscript presents similar efforts and technologies found in the literature (Sect. 2), the action research methodology adopted in this work, the details of the resulting system (Sect. 3) and a discussion of our findings with respect to the current state of the art (Sect. 4).

2 Background work

There are quite a few studies elaborating on the needs of people with hearing impairment and the conditions they face when they need to contact the emergency services. Overall, researchers identify poor accessibility and the need for the development of an effective emergency communication system. Reeves et al. [15] found that deaf or hard of hearing people has significantly less access to primary care and emergency services, facing difficulties at all stages of the process of health services. Similarly, the Northern Virginia Resource Center for Deaf and Hard of Hearing Persons [11] identified weaknesses in emergency response infrastructure and presented an extensive list of

recommendations to ensure the reliability and availability of this infrastructure [11].

In terms of empirical work targeting the development and evaluation of relevant applications in this area, a few efforts have been made, while the state of the art is still in its infancy. To name a few examples, the work of Buttussi et al. [2] focused on language barriers between emergency medical responders and hearing-impaired people. The idea was for the emergency medical responders to be able to ask their deaf patients some basic questions such as location and intensity of pain to help them identify the right pathology and proper treatment. The system was developed for PDAs, and it allowed health professionals to communicate with deaf patients with the use of preproposals relating to the emergency in sign language.

In their study, Zafrulla et al. [19] used the TTY/TDD (telecommunication device for the deaf) technology and developed an emulator for Symbian (Nokia) to allow deaf users to communicate directly with the emergency services using SMS. Also, a group of researchers at the University Trás-os-Montes e Alto Douro [12] have developed SOSPhone, a mobile application that allows emergency calls from users with hearing disability or speaking difficulties. The application uses icons to represent the type of the event and can send an SMS message to the emergency center that contains the selected information, the user profile and the user coordinates if available. However, evaluation data showed that the use of SMS messages may involve risks in the process, because it does not ensure a safe and timely delivery of the message [10]. It also showed a large percentage of failed attempts in some scenarios, without a clear explanation of the reason [12].

The study of Weppner and Lukowicz [18] describes the design, implementation and evaluation of a mobile application that has been introduced as the official app for emergency calls in Germany. The user selects the type of assistance required, and the system automatically creates a voice message containing the characteristics of the event. The message is then repeated until a response from the emergency services is recorded. The system was studied on different devices and conditions ranging from silence to people who spoke from a distance of 1 m. Although researchers claim that the level and the sound quality were adequate, data on noise levels (dB) and the precision of the result were not reported. Furthermore, the program REACH112 (Responding to All Citizens needing Help) was a 3-year pilot project applied in Sweden, UK, Holland, France and Spain allowing disabled users to communicate directly with emergency services. The pilots have been implemented including various scenarios. In France, the implementation was done by combining (1) operators who are deaf and use sign language in video and messages and (2) operators who are not deaf and use sound and messages.

In the Netherlands, the implementation was done using SMS. In Spain, the implementation was based on video relay services (video relay center) as a link between the deaf caller and the corresponding operator [14]. Also, in their study, Liu et al. [9] evaluated a mobile interface simulator, namely Peace Phone which was designed for people with hearing disabilities. Results showed that users appreciated features such as the direct interaction, shortcut keys for reporting emergencies, the ability to receive alerts for emergencies in the event of fire and operation of the outside door bell.

In the field of emergency services and crisis management in general, Díaz et al. [6] [17] analyzed the possibility of involving citizens on crisis management. They proposed a theoretical framework for the contribution of information and improving communication and cooperation between citizens and service agents during these crisis situations. The issue of inclusion of people with disabilities, however, was not considered in this work. Similarly, Aloudat and Michael [1] examined the emergency services implementation issues through the mobile networks of Australia, with a view to implementing an integrated early warning system for mobile devices; yet it is not clear how people with (hearing or other) disabilities could benefit from this warning system.

In the literature examined, there is sufficient evidence of the severity of the access problems faced by people with hearing disabilities seeking help from the emergency services. Although a few efforts are recorded, there is no universal framework. Fragmentation of solutions, each with its pros and cons, does not help addressing the problem. For example, the implementation using translators or other intermediary tools, such as the pilot implementation of 112 in Spain and France, does not take into account the existence of many different dialects of sign language in the

EU and is in contrast with findings suggesting that deaf users prefer to use communication technologies that do not rely on sign language [4]. Using SMS as a primary means of communication, such as in the pilot implementation of 112 in the Netherlands, may have negative results because many people with disabilities are not good with using the written language [7]. Sending–receiving an SMS may also have significant delays in case of emergency [3], [10]. Overall, our review of the literature regarding inclusive access to emergency services shows that, although a few efforts have been made, there is currently no universal solution, but rather many fragmented ones with proven limitations. In this action research work, we aimed to build a system to address this immediate need.

3 Methodology

Action research is practical and applied and has the following four characteristics: (1) has practical nature, investigating problems related to real situations; (2) aims to bring change, by fully addressing the problems investigated; (3) involves a cyclic process of design and evaluation in which findings lead to improvements or changes, which are under investigation in the next cycle; and (4) participants are determinant, by being active in all stages of research [5]. Within this notion, the present study was completed in four cycles of design, development and evaluation with the involvement of 74 hearing-impaired users and three officers from the Cyprus Police (Emergency Response Unit). Data were collected in each cycle, and findings lead to improvements of the system, which was subject to investigation in the next cycle, until all requirements were met (Fig. 1).

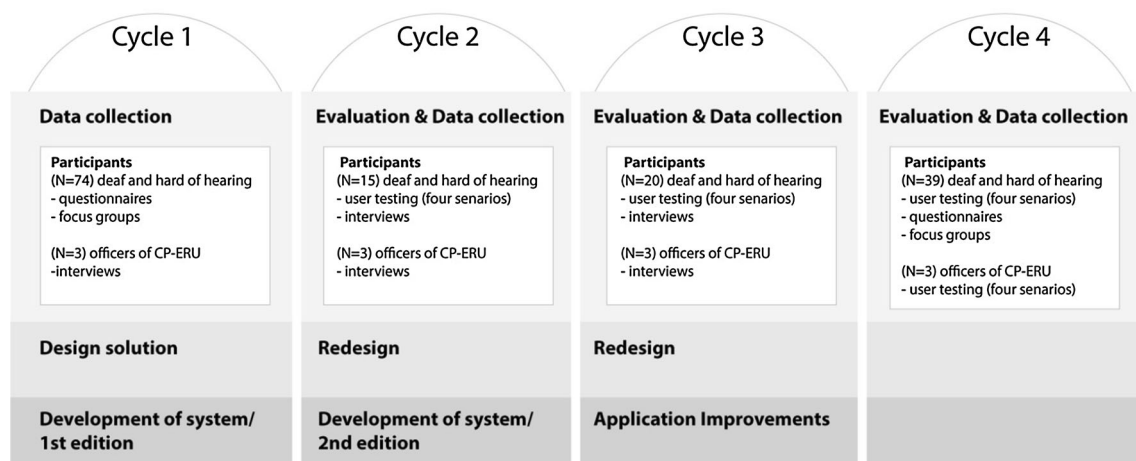


Fig. 1 Action research—the cyclic process of design and evaluation

3.1 Cycle 1

This cycle aimed to define the problems that deaf and hearing-impaired people face in accessing the emergency services and to suggest possible solutions. Cycle 1 involved a total of 74 participants—61 (82.4%) deaf and 13 (17.6%) hard of hearing—with a balanced gender split—35 (47.3%) men and 39 (53.7%) women. Data about their needs were collected via questionnaires and focus groups during face-to-face meetings. It was notable that how all participants confirmed the literature findings that reaching 112 for them requires the help of intermediaries. Additionally, three officers from the Cyprus Police Emergency Response Unit (CP-ERU) provided input in Cycle 1 through personal interviews focused on the problems they face in including deaf citizens in the emergency process. The data collected led us to the identification of a set of goals for the needed system as follows:

1. Be simple to use regardless of age or user skills, particularly language and writing skills.
2. Allow immediate access to emergency services without the need for intermediaries.
3. Allow the necessary data to reach the emergency services so as response to the event is possible.
4. Work with simple existing infrastructure available in all EU emergency services.
5. Be well received by interested parties/stakeholders (therefore more likely to be adopted).

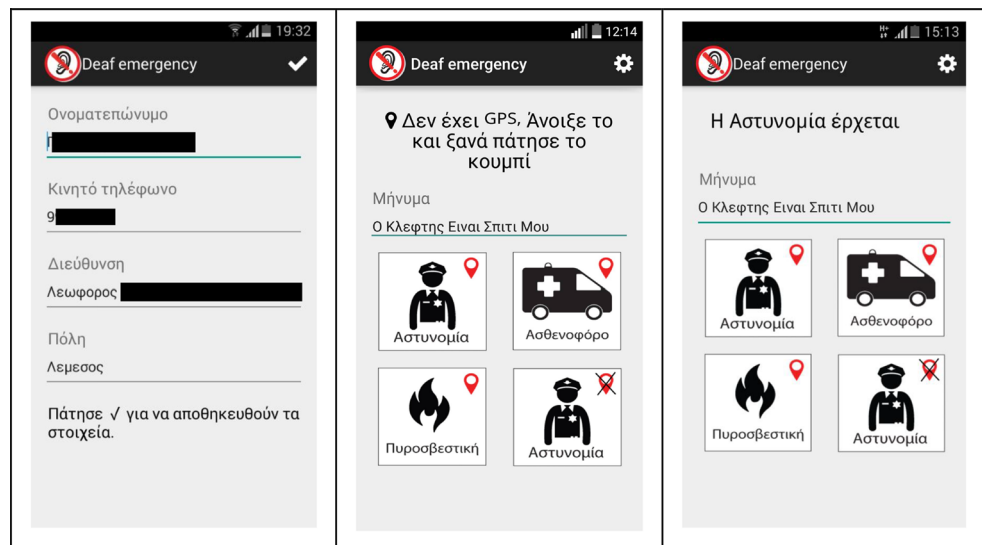
Cycle 1 led to the design of a functional prototype of the system which was then tested in Cycle 2. Briefly, the system is composed of two parts: (1) a mobile application for deaf users that collects the event data and sends it to a specific address on a cloud server and (2) a data

management application at the end of the police, recording events and their resolution into a database. Due to the type of communication required in emergency situations, when users might be in a state of panic, danger or injured, the mobile application is based on simple and fast data manipulation using icons. This is consistent with the general principle of Minimal Attention User Interfaces (MAUIs), which specifies that time should be minimized for interaction with the device [13]. The mobile application was developed using android studio considering the large market share for Android OS. According to Gartner [8], the rate of new devices running android in 2015 was 80.8%, irrespective of manufacturer, with the second being iOS with 15.3%. Consistent with these statistics were our own data collected in Cycle 1, with 66.2% of our deaf participants reporting having an android smartphone as opposed to 12.2% having iPhones.

3.2 Cycle 2

Cycle 2 focused on the refinement of the mobile application. The user has to set up the mobile application (only the first time of use) with full name, mobile phone number and address. The main screen of the application contains three predefined function buttons for emergency calls: (1) police, (2) ambulance and (3) the fire department, using GPS for tracking the location of the incident (Fig. 2). By pressing one of the buttons, the application creates an XML that contains all the elements of the event and sends to a specific address. A fourth button (no-GPS case) can be used to call without GPS, in case the device does not have GPS or the user is located in a space where communication with satellites is not possible. In this case, the application requires the “Message” field to be completed by the user.

Fig. 2 Mobile application setup (left), no-GPS found (middle), message texting (right)



This is a plain text field for short phrases; it becomes necessary in the no-GPS case as the system will not automatically send the coordinates of the incident but rather, the user needs to, at least, record his/her position. This is explicitly stated in the textbox where the user is prompt to type (“No GPS—Please record your position”). Yet, if the user wishes, he/she can submit more details in this textbox to facilitate better description of the event.

Cycle 2 evaluation involved a subgroup of 15 deaf participants, aged from 21 to 64 years old. The system was examined by each of them completing four scenarios without any help, aiming to uncover any weaknesses or problems encountered. The scenarios included:

- (S1) There is an accident on the motorway (police call).
- (S2) There is a fainted boy (ambulance call).
- (S3) There is a fire in a rural area (fire call).
- (S4) You came home and you realize that it has been burgled; your mobile does not have GPS (police call without GPS).

Data were collected using a camcorder “Noldus” on a mobile device (Fig. 3). Moreover, the users participated in interviews to discuss problems encountered in using the application and potential improvements overall.

In general, the users were able to respond to all scenarios with no difficulty. Their verbal comments (confirming the researchers’ observations) revealed that (1) a confirmation for the “sent message” was desired and (2) in S4, a number of users were concerned about typing the message syntactically correctly to be understandable or questioned themselves about the need for typing something. This confirmed how deaf users needed something very simple to send the details of the incident, preferably without the need for written language. In sum, data from Cycle 2 led to a new version of the mobile application, which had the following improvements.

1. Once the XML is sent, the screen displays a confirmation “Message was sent.”



Fig. 3 Cycle 2 evaluation with Noldus camera

2. In the no-GPS case, if the “Message” field is not completed the user receives the error message “Enter your message.”

3.3 Cycle 3

Cycle 3 examined the refined mobile application as well as the data management application. For the first part, a new subgroup of 20 deaf users (ages 24–61) participated in the evaluation of the mobile application using the same scenarios and data collection procedures as in Cycle 2. Cycle 3 reveals no issues with using the mobile application.

For the second part, a meeting was held with the three CP-ERU officers to consider their input regarding the system functionality. The data management application makes use of JavaScript to retrieve and display data, and PHP for XML management and data recording into a database (MySQL). The application checks for new records (every 10 s) and displays the cumulative number of events, listed in three categories: all events, outstanding and resolved. The emergency services operator can check a pending record; the application automatically displays all data sent by the user, including the map, type of incident (determined by the key select, e.g., fire department), date and time sent, mobile phone number, user’s full name, address and user’s message if one exists (Fig. 4). Upon action (e.g., sending the police to the place), a “resolve” button is used for closing the incident. The feedback of the CP-ERU officers revolved around the need for the operator to communicate with the users to notify them about some events. This input led to improvements of the management application, as follows:

1. When the incident’s data are seen (opened) by the operator, the system automatically alerts the user that “Message was received.” At the end of the user, this message appears at the top of the mobile screen (Fig. 4).
2. The emergency services operator can send a predetermined system message to the user such as “The Police is coming,” “The Ambulance is coming” or “The Fire truck is coming,” or he/she can type a customized message (Fig. 4).
3. The system allows the recording of all actions taken including messages exchanged between the user and the emergency services.

3.4 Cycle 4

A final round of evaluation was conducted in Cycle 4 with 39 deaf participants (ages 22–68, mean age = 42) for whom the system was new, i.e., excluding the 35 users who

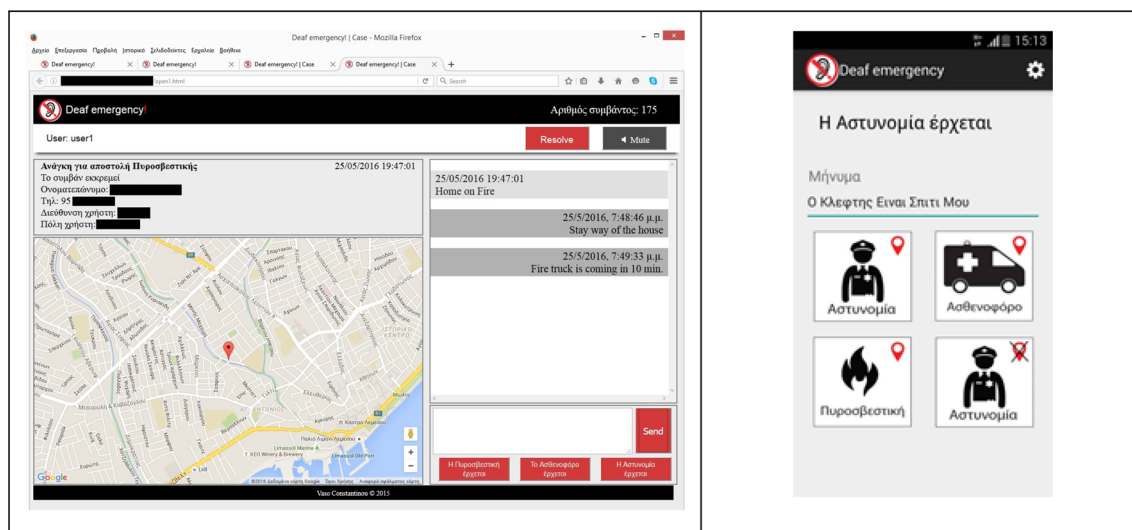


Fig. 4 Data management application with messaging from the operator (left); message received at the end of the user (right)

had experienced a previous version of the system in Cycles 2–3. Android phones (90%) were dominant, while 5% had a Microsoft phone and another 5% had previous generation phones (not smartphones). Using the Noldus camera, five usability-type measures were gathered: (1) time for completing four scenarios (same scenarios used in Cycles 2 and 3); (2) failures in completing the scenarios and specific errors repeated more than once; (3) number of successful/unsuccessful attempts to reach the emergency services. Moreover, the participants completed a usability satisfaction scale (adapted from Lewis [20], assessing the extent to which users were satisfied with the usability of the system, e.g., “This application was easy to use” (see Table 2). Qualitative data were also collected via focus groups at the end of the experience. Last, the three CP-ERU officers were observed, using the system at their end and responding to the four testing scenarios as they (hypothetically) occurred, but also checking the recorded data later on upon the resolution of an event. The results of these measures are presented next.

3.4.1 Usability-type measures

Time for completing the scenarios A total of four scenarios (see Cycle 2 for scenarios) were completed by each participant without any help. The maximum time recorded for completing the scenarios was 70 s, when in S4 the user chose to type a detailed message together with reading all possible messages sent and received. The minimum time recorded was 20 s, when the user simply called for assistance by pressing a button. The mean completion time per scenario is presented in Table 1. An outlier case was excluded from the data, because during the completion of

Table 1 Completion time per scenario

	Scenario 1 (S1)	Scenario 2 (S2)	Scenario 3 (S3)	Scenario 4 (S4)	Totals
M	45.79	39.25	32.40	33.35	37.59
SD	13.36	13.63	11.64	10.03	13.14

the scenario, a phone call interrupted the process causing her to take much longer to complete the task.

Failure in completing the scenarios Only two such failures were recorded. Two of the users incorrectly completed S3 calling the police instead of the fire department. Yet, in both cases these users chose to type a message, with a proper description of the incident (i.e., although the call requested the help of the police, the text message contained enough information for the proper understanding of the fire incident from the side of the emergency services). Also there were no specific errors repeated more than once, across participants and scenarios.

Successful attempts to reach the emergency services Although two out of 39 deaf participants used “the wrong” button (see above), the message did reach the emergency services with the correct description of the event, and therefore, we may consider 100% success for reaching the emergency services.

3.4.2 Usability satisfaction scale

All participants ($N = 39$) completed the usability satisfaction scale. The internal consistency for the subscale was assessed and considered acceptable (Cronbach’s $\alpha = 0.74$). Individual item and scale statistics were then computed as shown in Table 2. The scale mean score (M scale = 6.90)

Table 2 Usability satisfaction scale–subscale statistics (N = 39)

		M	SD
Q1	I am satisfied with how easy it is to use this application	6.95	0.22
Q2	This application was easy to use	6.90	0.31
Q3	I am able to accomplish my goal quickly by using this application	6.60	0.82
Q4	I feel comfortable by using this application	6.90	0.31
Q5	The system gives error messages that help me correct my mistake	6.95	0.22
Q6	Every time I make a mistake when using the application, I can easily and quickly go back	6.90	0.45
Q7	I understand the information, messages on the screen and the icons of the application	6.95	0.22
Q8	The organization of the information on the application screens is clear	6.90	0.45
Q9	The interface of this application is pleasant	6.95	0.22
Q10	I would use this application in case of emergency	7.00	0.00
Q11	The messages on the screen are effective in helping me accomplish the tasks and the scenarios	6.90	0.31
Q12	Overall, I am satisfied with this application	6.95	0.22
Subscale statistics		6.90	0.37

was well above the midpoint of the seven-point response scale, with very little variation in the participants' views (SD scale = 0.37). This suggests that the technology was overwhelmingly positively endorsed by the participants.

3.4.3 Focus groups

At the end of the experience, qualitative data were collected via 30-min focus groups with 6–8 participants per group. The participants enthusiastically described the application as “*very easy to use*” and commented positively on the direct access to the emergency services without the need of an intermediary to provide the message to them. The participants greatly appreciated how the icon-based application frees them from having to write a text message while serving its purpose fast and accurately. Related to this were the views of two users who don't speak the official language of the country (Greek). Both of them pointed out how the intuitive icons and ability to send the event data without a written message enable equal and language-independent access to the emergency services. In sum, the application seems to be successfully used by anyone regardless of age (22–68), writing ability or language skills.

3.4.4 CP-ERU officers' observation

Last, three CP-ERU officers were observed using the system (responding to the four scenarios but also checking the recorded data later on) from the end of the emergency services. No difficulties were recorded in using the system; the officers reported being highly satisfied with its functionality.

4 Discussion

As of today, in case of emergency, deaf or hard of hearing people is not able to access the emergency services. That is, in cases of fire, accidents or criminal events, they do not have equal access to social support and infrastructure. Although the international legislation (e.g., UN Convention on the Rights of People with Disabilities) assumes inclusion and equal access, research internationally shows that the problem remains unresolved. While there have been a few efforts, there is no framework or universal solutions, but rather many fragmented ones. This manuscript described an action research study whose main outcome is a system that consists of (1) a mobile application that records and sends the details of an emergency event and (2) a central management system that handles these calls from the end of the emergency services. Results from the empirical evaluation demonstrate how the system can provide easy and direct access to emergency services, without the need of any intermediate, enabling the inclusion of these citizens. The solution presented has value beyond the current state of the art as summarized below.

- The system is effective. The final phase of evaluation involved 39 deaf or hard of hearing users completing four emergency scenarios with a success rate 100%. This is a notable progress given that similar studies recorded successful completion rates between 35 and 86% in varied scenarios and were, for the most part, conducted with non-deaf people [12].
- The system does not use intermediaries. Previous works showed that deaf and hard of hearing users are not in favor of implementations using translators or other intermediaries (e.g., 112 in Spain and France) and prefer to use communication technologies that do not

rely on sign language [4]. The present icon-based system gives direct access to emergency services.

- The system does not rely on the use of SMS. Because many people with disabilities are not good with using the written language [7], SMS cannot be the primary means of communication and may also result in significant delays in case of emergency [3]. The present icon-based system requires an SMS for the user to record his/her position only when GPS is not available.
- The system is fast. The implementation period of four scenarios ranged from 20 to 70 s with an average completion time of 38.25 s, which included calling for help, typing messages and reading all the relevant messages sent and received.
- The application is simple and easy to use by anyone regardless of age, writing ability or language skills. The system can send the data of the type of assistance required, even when the users are unable to complete the message field.
- The system can work with simple existing infrastructure available in all EU countries (i.e., a computer without specific processor requirements and a standard Internet connection) and does not require additional equipment and specialized staff at the end of the police Emergency Response Unit.
- The system allows the recording of detailed data of the incidents as well as actions taken for their resolution. Currently, the inability of the deaf to communicate directly with the emergency services leads to no registered statistics on incidents involving this special population in EU and internationally.

There is no doubt about the severity of the access problems faced by people with hearing disabilities seeking help from the emergency services across Europe and internationally. Results from this work demonstrated how a simple, icon-based system can provide easy and direct access to emergency services, without the need of any intermediate, enabling the inclusion of these citizens in this critical process. Given the encouraging results of this study, future investigations could expand and examine how the system can meet the needs of other vulnerable groups of citizens who have similar needs, such as people with speech disabilities, dementia or Alzheimer.

Acknowledgements Authors acknowledge travel funding from the European Union's Horizon 2020 Framework Programme through NOTRE Project (H2020-TWINN-2015, Grant Agreement Number: 692058).

References

1. Aloudat, A., Michael, K.: Toward the regulation of ubiquitous mobile government: a case study on location-based emergency services in Australia. *Electron. Commer. Res.* **11**, 31–74 (2010)
2. Buttussi, F., Chittaro, L., Carchietti, E., Coppo, M.: Using mobile devices to support communication between emergency medical responders and deaf people. *Proceedings of the 12th International Conference on Human Computer Interaction with Mobile Devices and Services—MobileHCI '10* (2010)
3. Chiu, H., Liu, C., Hsieh, C., Li, R.: Essential Needs and Requirements of Mobile Phones for the Deaf. *Assist. Technol.* **22**, 172–185 (2010)
4. Cromartie, J., Gaffey, B., Seboldt, M.: *Evaluating Communication Technologies for the Deaf and Hard of Hearing* (2012)
5. Denscombe, M.: *The Good Research Guide: For Small-Scale Social Research Projects*. McGraw-Hill (2014)
6. Díaz, P., Aedo, I., Romano, M., Onorati, T.: A framework to integrate large-scale participation in Disaster and Emergency Management. *Conference: Workshop on Large-Scale Ideation and Deliberation Systems*. 6th International Conference on Communities and Technology (2013)
7. EENA European Emergency Number Association: 112 Accessibility for People with Disabilities (2012). http://www.eena.org/uploads/gallery/files/operations_documents/2012_01_13_112accessibilityforpeoplewithdisabilities.pdf
8. Gartner Says Emerging Markets Drove Worldwide Smartphone Sales to 19 Percent Growth in First Quarter of 2015. <http://www.gartner.com/newsroom/id/3061917>
9. Liu, C., Chiu, H., Hsieh, C., Li, R.: Optimizing the Usability of Mobile Phones for Individuals Who Are Deaf. *Assist. Technol.* **22**, 115–127 (2010)
10. Meng, X., Zerkos, P., Samanta, V., Wong, S., Lu, S.: Analysis of the Reliability of a Nationwide Short Message Service. *IEEE INFOCOM 2007—26th IEEE International Conference on Computer Communications* (2007)
11. Northern Virginia Resource Center for Deaf and Hard of Hearing Persons.: *Emergency Preparedness and Emergency Communication Access* (2004) <http://www.eadassociates.com/DHHCANReport.pdf>
12. Paredes, H., Fonseca, B., Cabo, M., Pereira, T., Fernandes, F.: SOSPhone: a mobile application for emergency calls. *Univ. Access Inf. Soc.* **13**, 277–290 (2013)
13. Pascoe, J., Ryan, N., Morse, D.: Using while moving: HCI issues in fieldwork environments. *ACM Trans. Comput. Hum. Interact.* **7**, 417–437 (2000)
14. REACH112 Responding to All Citizens Needing Help: Final Project Report (2012). http://www.reach112.eu/ressource/static/files/reach112_d8.5_final_report_on_reach112_v1.2.pdf
15. Reeves, D., Kokoruwe, B., Dobbins, J., Newton, V.: *Access to Primary Care and Accident & Emergency Services for Deaf People in the North West. A report for the NHS Executive North West Research and Development Directorate* (2002)
16. Republic of Cyprus.: *A Law to provide for persons with disabilities* (2000), <https://www.google.com.cy/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjlx-fs3afPAhVFCMAKHOMDGwQFggBMAA&url=http%3A%2F%2Fwww.mlsi.gov.cy%2Fmlsi%2Fdsid%2Fdsid.nsf%2F%2F%2F485A5B8DC1DC847C2257AA30026CC4F%2F%2F%2F%2520Law%2520to%2520provide%2520for%2520persons%2520with%2520disabilities%25202000-2007.docx&usg=AFQjCNFGbfpFXIoWH4wyrI09m7vLiuDQGA&cad=rja>
17. Romano, M., Onorati, T., Díaz, P., Aedo, I.: Improving emergency response: citizens performing actions. *11th International ISCRAM Conference. Proceedings of the 11th International ISCRAM Conference* (2014)
18. Weppner, J., Lukowicz, P.: *Emergency App for People with Hearing and Speech Disabilities: Design, Implementation and Evaluation according to Legal Requirements in Germany*. *Proceedings of the 8th International Conference on Pervasive Computing Technologies for Healthcare*. (2014)

19. Zafrulla, Z., Etherton, J., Starner, T.: TTY phone. Proceedings of the 10th International ACM SIGACCESS Conference on Computers and Accessibility—Assets '08 (2008)
20. Lewis, J.R.: IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use. *Int. J. Hum. Comput. Interact.* **7**, 57–78 (1995)