CBRNe, a universally designed app for that?

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ABSTRACT

While a wide range of disaster apps are currently available, few address the topic of CBRNe (Chemical, Biological, Radiological, Nuclear and explosive) risks and threats. The proven value of disaster apps in emergency management and the unique ways in which citizens prepare for and respond to CBRNe incidents merit that such an app exist. However, disaster apps also have their limitations, namely uptake and accessibility. The PROACTIVE project is filling these gaps by co-creating together with vulnerable groups an accessible CBRNe disaster app. This article examines the results from four workshops held with the potential end-users recruited from vulnerable groups. Following the MoSCoW methodology, requirements were established and their relevance to the Universal Design principles discussed. For instance, it was found that the app Must have a *less chaotic interface* which would help meet the principle of simple and intuitive use. Lastly, the app redesign is showcased.

Keywords

CBRNe, Universal Design, disaster apps, co-creation, user interface

INTRODUCTION

Smartphone applications for disaster preparedness and response, commonly referred to as disaster apps, are widely available on various app stores. For example, a 2014 search on an app store found 683 results (Bachmann et al., 2015) and a 2017 literature review on the topic found 57 unique apps being discussed (Tan et al., 2017). The available apps:

- Cover the entire disaster management cycle (preparedness, response, recovery, mitigation) (Tan et al., 2017);

- Can efficiently spread and collect information (Bachmann et al., 2015; Aydin et al., 2016);

- Provide a channel for distributing (early) warnings (Douvinet, 2018);

- May use GPS technology to reach citizens in a given area,

- Reduce anxiety (Bossu et al., 2018);

- Some provide users with information about how to act prior, during and after a disaster (Fallou et al., 2019).

Despite these advantages to using disaster apps, few available Chemical, Biological, Radiological, Nuclear and explosive (CBRNe) smartphone apps on either Google play or Apple app stores could be considered a disaster app (Petersen et al., 2021). Instead, they tend to be reference or training apps (e.g., EU CBRNE Glossary), apps

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which are part of a larger CBRNe monitoring system (e.g., PlumeSIM-SMART) or apps designed for a CBRNe conference (e.g., 2021 CBRN).

CBRNe incidents present unique challenges for disaster management and crisis communication. This is due in part to the fact that CBRNe risks are considered 'dread' risks, which are defined by lack of perceived control, catastrophic potential, and fatal consequences (Slovic, 2002; Slovic et al., 2004). CBRNe events may be hard to detect or even invisible, have unknown consequences of exposure and often result in delayed effects from contamination. Furthermore, public awareness about CBRNe incidents is low. Generally, few are aware of the actions taken by first responders, such as the wearing of protective hazardous materials suits when dealing with a contaminated area, or requirements of casualties, such as disrobing (Hall et al., 2020). Therefore, citizens depend more than ever on the type of communication, tactics, techniques and technology employed by practitioners (Hall et al., 2020). For instance, seeing practitioners arrive in hazmat suits on the scene while waiting to begin decontamination is seen as further fear inducing (Carbon et al., 2021). These communication challenges would be helped by providing the general public with a dedicated CBRNe disaster app which could be used before and during an incident.

Disaster apps do however have their limitations. Indeed, apps are based on an "opt-in" system, whereby a smartphone owner must download the app. A recent representative study of German citizens found that only 16% have downloaded a disaster app (Kaufhold et al., 2020). However, having downloaded the app is not enough as users should familiarise themselves with the app before the crisis hits as to be able to use it well under stressful crisis conditions (Stølen & Nilsson, 2011; Tan et al., 2017). Once the app has been downloaded, there is still the issue of getting the users to actually use the app. Data from 2018 showed that 21% of users abandon an app after just one use (Upland, 2021a) and 71% of apps do not last past 90 days (Upland, 2021b). In order to overcome the hurdle of opt-in, research demonstrates for both general smartphone apps and disaster apps specifically, involving users in development ensures their uptake and use (Kouadio, 2016; Pylvas et al., 2018; Tan et al., 2017).

Another limitation is lack of accessibility for disaster apps. Accessibility is a key component of social sustainability and inclusiveness, contributing to usability and durability – as stated in the European Accessibility Act (European Commission, 2019). A recent literature review on the Universal Design of Information and Communication Technology (ICT) for emergency management found that only 36 papers have been published on the subject since 2009 (Gjøsæter et al., 2021). The Web Content Accessibility Guidelines (WCAG) are a common metric by which to measure internet-based content such as web platforms and smart phone apps. Recent research using WCAG to evaluate five different disaster information sharing web-based tools found that none of the tools meet the WCAG criteria and recommends that Universal Design principles be included from the beginning of ICT tool development (Radianti et al., 2017). Universal design is defined as the design of products and environments to be usable to the greatest extent possible by people of all ages and abilities. It is based on the following seven principles as elaborated by Connell et al. (1997):

- Equitable use;

- Flexibility in use;

- Simple and intuitive use;

- Perceptible information;

- Tolerance for error;

- Low physical effort;

- Size and space for approach and use.

Unfortunately, rarely are digital tools for emergency management, including public facing disaster apps, designed with the Universal Design principles in mind (Gjøsæter et al., 2021). It may be argued that Universal Design principles should have a key place in disaster apps, as when a disaster occurs, anxiety is likely to be high and therefore comprehension levels reduced. This is an effect known as situational disability as indeed circumstances surrounding a disaster may lead to temporary impairments, such as noise and smoke temporarily reducing hearing and vision among those present (Gjøsæter et al., 2019).

PROACTIVE AND THE CIVIL SOCIETY ADVISORY BOARD

The EU H2020 project PROACTIVE (PReparedness against CBRNE threats through cOmmon Approaches between security praCTItioners and the VulnerablE civil society) presents a novel solution to i) fill the CBRNe disaster app gap and ii) overcome the identified accessibility barriers when developing such an app. In order to ensure that the PROACTIVE CBRNe app will meet the criteria associated with universal design and WCAG, the

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PROACTIVE Civil Society Advisory Board (CSAB) is involved in a co-creation process. The CSAB is made up of civil society groups who represent a wide range of citizens of different ages, backgrounds and abilities. The PROACTIVE project defines citizens as members of the public and also includes vulnerable citizens with needs that differ to the average population. Vulnerable groups may include children, pregnant women, persons with disabilities, chronic medical disorders or addiction, older persons with functional limitations and health restrictions, institutionalized individuals as well as their companions and the people that care for them. Vulnerable citizens also include persons with limited proficiency of the respective national languages or with restrictions regarding use of transportation.

At the time of this writing (March 2022), the CSAB has 48 members from a diverse range of civil society groups, from organisations focusing on disability rights, senior citizens, youth or refugees, to citizen science projects and research groups from relevant areas of study (e.g., vulnerability).

METHODOLOGY

The PROACTIVE prototype disaster app that is the focus of this paper was developed based on a set of basic requirements which were defined during a previous workshop with CSAB members. More details about this process can be found in Petersen et al., 2021. The prototype app in this paper has been developed as a web app, accessible from any web browser, for the ease of beta testing. It will be converted into a mobile app in a future stage. The current paper presents the completed research cycle of testing the prototype app and subsequent app redesign based on end-user feedback.

Four workshops with end-users were held in 2021 (details in Table 1). Recruitment for participants in these focus groups was carried out via the CSAB. Participants thus represent a given civil society organisation.

Table 1 Workshop details

Date of workshop	Number of participants	Type of organisation & number of representatives
26 February 2021	10	• Academic institutions/ research groups (on e.g., accessibility, vulnerability)

12 May 2021	4	• Blind/visually impaired persons
		    o Two representatives
		 • Autistic persons
		    o One representative
		 • Persons who use wheelchairs
		    o One representative

26 May 2021	9	• Blind/visually impaired persons
		    o Two representatives
		 • Deaf/hard of hearing persons
		    o Three representatives, each from a different organisation
		 • LGBTQIA+ community
		    o One representative
		 • Persons with physical disabilities
		    o Three representatives from two organisations

8 June 2021	6	• The homeless
		    o One representative
		 • Pregnant women
		    o Two representatives from two organisations
		 • Older persons
		    o One representative
		 • Visually impaired guide dog users
		    o One representative
		 • Immigrants
		    o One representative

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In total, four workshops were held online. The workshops were comprised of an interactive session where participants were asked to complete certain tasks by using the prototype app, followed by a focus group discussion.

Interactive App Session

Participants connected to a live, beta version of the app (Figure 1) by opening a link on a web browser of their computer, tablet or mobile phone. They performed 4 tasks live during the session. Participants were free to perform or not perform any task. The tasks were:

1. What information can you find in the app regarding the PROACTIVE Project and can you send the contact Project Coordinator an email?

2. You are curious about what to expect or what to do if you were ever involved in a CBRNe incident. What information can you find in the app regarding CBRNe Information? Were you able to download the information and save it to your device?

3. What information can you find about a recent CBRNe incident (what date and time the incident was reported, what the incident involves)? Were you able to find a map showing multiple past incidents?

4. Follow the process to share information with a Law Enforcement Agency.

The participants were given the option of registering and creating an account through the app. This is because in order to perform Task 4, one must be a registered user for security reasons. However, the registration process is outside the scope of this paper.
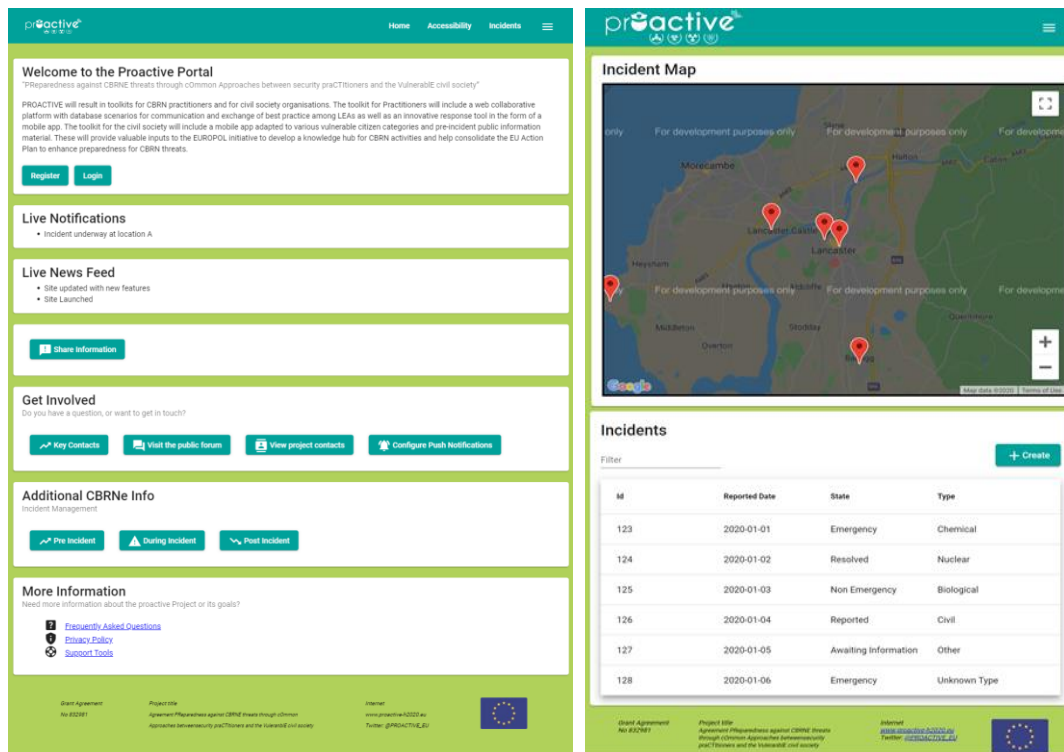

Figure 1 First iteration of the PROACTIVE app homepage and incident map page

Focus Group Interview Guide

The interactive session was followed by a group discussion using the following interview guide:

1. Based on first impressions, what design improvements would you make?

2. Are there any additional features you would like to see in the App?

3. How could the App better support accessibility?

4. Now you understand a little bit more about the App, how many stars would you give it?

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We combined the data collected from the four workshops. The input collected was documented and validated using the MoSCoW (Must have, Should have, Could have, and Won't have) methodology (Clegg et al., 1994). These results were then analysed through the prism of the 7 principles of Universal Design (Connell et al., 1997).

RESULTS

End-user Requirements

For Task 1, participants generally found it difficult to locate the contact information. For Task 2, participants easily found the CBRNe information but had difficulty downloading it. For Task 3, participants were mostly able to find information related to CBRNe incidents but took issue with the reliance on the map and pointed out that not all people can see and/or use a map. For Task 4, participants easily found where to report an incident. However, they were uncertain if the information they reported was successfully submitted, due to a lack of feedback from the app. Further, while the GPS functionality of reporting an incident was well liked, many experienced technical difficulties using it.

Based on feedback during the interactive app session and the responses given to the first three interview guide questions, Table 2 showcases the end-user requirements based on the MoSCoW methodology. No requirements were listed as *Won't have*. The requirements listed in the table reuse the language which best reflected what was said by participants in the workshops. For example, the requirement of *less chaotic interface* comes from one workshop participating saying "the layout is very chaotic" and another requesting that the app be "visually less chaotic". Once collected, these requirements were then used to update the app. For the fourth interview guide question, when asked to rate the app out of five stars, the app received an average of 2.7 stars.

Table 2 MoSCoW requirements

Must have	Should have	Could have

• Compliance with international standards for accessibility (e.g., WCAG 2.1)
• Improve accessibility features:
  • Ability to zoom while ensuring high image quality
  • A high contrast option
  • An Easy Read option
  • Audio information
  • Basic wording
  • Bigger text (large font)
  • Bigger buttons, icons & symbols
  • Colour blind compatibility
  • International Sign Language
  • Pictures, pictograms
  • Text-to-speech
  • Translation
• A less chaotic interface
• An uncomplicated structure
• Specific information on what is happening and how to act
	• A search button
	• Less confusing icons (e.g., contact icon should be an envelope, not an arrow)
	• Less reliance on maps
	• Less text
	• Mental health support message
	• A symptoms checklist
	• Hospital lists
	• Links to other useful apps
	• Ways to contact relatives/loved ones
		• Social media integration (post information to a given social media account)
		• Proof of decontamination

Requirements from End-users Categorized as Universal Design Principles

Overall, the majority of the MoSCoW requirements from the CSAB can be categorised as belonging to one or several Universal Design principles, as seen in Table 3. Certain new features which do not fit into one of the Universal Design principles (e.g., specific information on what is happening and how to act, mental health support message, hospital list, symptoms check list, proof of decontamination) if chosen to be implemented will be done so in compliance with said principles. Indeed, many of these new features are content based and therefore ensuring

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that they are written with e.g., basic wording and in a large font size would therefore ensure their fit-for-purpose with a universally designed app.

Table 3 MoSCoW requirements categorized into Universal Design principles

Universal Design Principle/ MoSCoW end-user requirement	Equitable use	Flexibility in use	Simple and intuitive use	Perceptible information
Must have	• Audio information • Colour blind compatibility • Compliance with international standards for accessibility (e.g., WCAG 2.1) • International Sign Language • Text-to-speech	• Ability to zoom while ensuring high image quality • An Easy Read option • A high contrast option • Translation	• A less chaotic interface • An uncomplicated structure • Bigger text (font size) • Bigger buttons, icons and symbols	• Ability to zoom while ensuring high image quality • An Easy Read option • Audio information • Basic wording • Bigger text (font size) • Bigger buttons, icons and symbols • A high contrast option • Pictures, pictograms • Specific information on what is happening and how to act Translation • Text-to-speech
Should have	• Less text	• Less reliance on maps	• Less confusing icons (e.g., contact icon should be an envelope, not an arrow) • Links to other useful apps • A search button • Ways to contact relatives/loved ones	• A search button
Could have			• Social media integration (post information to a given social media account)	

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Applying the Universal Design Principles in the App Redesign

Redesign of the App Based on the MoSCoW Results

In order to achieve the Universal Design principle of equitable use, the PROACTIVE app is intended to be a single app for all users (meaning that there won't be different versions to download to accommodate any given vulnerability). This has been done by ensuring that the app uses basic wording and less text. This increases accessibility for those with intellectual disabilities and children as well as any citizen who might use the app during a CBRNe incident and have a situational disability (Gjøsæter et al., 2019).

The app is applying a colourblind friendly colour palette, ensuring compliance with text-to-speech readers, avoiding flashing images, and will have information materials that are supported with audio and sign language. As such, users who are colourblind, blind or partially sighted, epileptic or hearing-impaired can all use the app equitably. For compliance with text-to-speech readers, the formatting of headings, lists, graphics and logos, sequences and hierarchies was completed. Compatibility was tested using a screen reader and a keyboard. When it comes to content, the data, whether that be pre-incident information materials or a list of local hospitals, will be available as plain text built into the web page as well as a downloadable document.

Flexibility in use has been achieved in the app redesign by embedding colour contrast ratios in the HTML coding in order to provide a high contrast option. The app will also be recoded to allow for zooming for partially sighted persons. Furthermore, the reliance on the interactive map to find and report incidents has been reduced and alternative options for using these features have been implemented.

Simple and intuitive use has been achieved through the homepage reorganisation (Figure 2). The homepage now has a less complicated structure and a more ergonomic interface. The homepage now highlights the three main features of the app:

1.   Providing information about past and ongoing CBRNe incidents;

2.   The ability to report;

3.   Providing preparedness information.

This has been done by making these items more clearly visible and using larger font sizes, bigger buttons and bigger icons. For example, the "report an incident" button is now a standalone button, no longer under the heading of "get involved," and has been coloured as a different colour (in this case red) and shade (lighter) than the other buttons to demonstrate its importance.

Citizens are not expected to come to the PROACTIVE app in order to learn more about the PROACTIVE project, but rather for traditional disaster app reasons (pre-incident information, receiving and reporting information about disasters). Thus, the homepage no longer describes the project and instead describes the app:

The PROACTIVE portal is your one-stop hub for all things Communication in relation to CBRNe incidents. The terms CBRNe refers to any Chemical, Biological, Radioactive, Nuclear and Explosive incidents and through the portal you can:

- *Report and receive live notifications about ongoing incidents in your area;*

- *Access pre-incident information on incidents;*

- *Interact with Law Enforcement Agencies and Civilian Organisations.*

Many of the updates in the app redesign that are relevant for the universal design principles of equitable use and flexibility of use overlap with the principle of perceptible information. Further, whether or not the information is perceptible depends on two factors: through the development of the app itself and through the content provided on the app. When it comes to app development, the app has been coded to be text-to-speech/screen reader and keyboard compatible, the font, buttons, icons and symbol size has been increased, high colour contrast has been embedded, self-speaking links have been established, etc.

When it comes to accessibility through content, the PROACTIVE project has been co-designing pre-incident materials alongside vulnerable groups in order to create "specific information on what is happening and how to act" (Nicholson et al., 2021). The app also supports the uploading of audio files and sign language videos for such information.

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Addressing Other Design Principles Not Included by End-users

The principle of tolerance for error is being addressed when reporting an incident. Information that is reported must be approved of by the local law enforcement agency running the app. To ensure low physical effort, the PROACTIVE app has further minimized clicks (part of the requirement less chaotic interface) and has ensured compatibility with assistive technologies (part of requirement text-to-speech). Similarly, the principle of size and space for use is being addressed by ensuring that the app is compatible with multiple devices and is available as both a web-platform and a smartphone application. This allows the end-user to choose the size and space of the device.
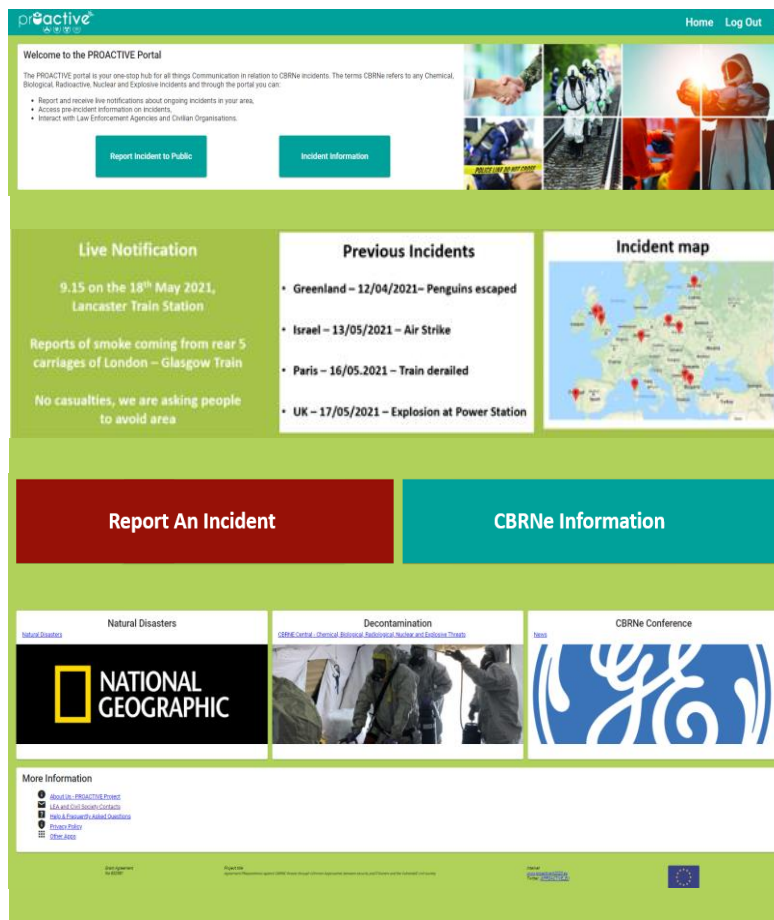

Figure 2 Second iteration of the PROACTIVE app

DISCUSSION

Co-design Demonstrates Importance of Accessibility Features but is Not a Panacea for Universal Design

Out of the 16 Must have requirements, 13 are specifically related to accessibility. The accessibility issues came up organically during the interactive session. While performing the various tasks the participants already noticed areas where accessibility must be improved. For example, when Task 3 asked participants to find the map, participants immediately voiced their concerns that blind/partially sighted persons or some persons with intellectual disabilities would not be able to use the information presented in map form.

As seen in Table 3, the focus on accessibility only led to participants voicing requirements in line with four universal design principles, namely equitable use, flexibility in use, simple and intuitive use and perceptible information. It would seem that Simple and intuitive use is the universal design principle that is best served by a co-creation process. Workshop participants identified confusing icons and these were changed. For example, the contact icon was depicted as an arrow and has now been replaced with an envelope, the icon which the participants felt best depicted the idea of contact. Another example was that the exclamation mark by *share information* made it seem that one would receive information and not report it to the police. This also allowed us to identify that the app presented too much information about the PROACTIVE project instead of accomplishing its objectives. Equitable use and perceptible information had many overlapping requirements. This seems to be due to the fact

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that in order to ensure a piece of information is perceptible, you also have to ensure that it is able to be perceived by many, therefore also respecting equitable use.

Three universal design principles did not come up organically during the workshops. These are tolerance for error, low physical effort and size and space for use. The principle of tolerance for error did not come up in the engagement activity discussions. This could be because having a "back" and/or "undo" buttons/controls are part of the larger device and not implemented in a given disaster app. Since the design of the device (phone, tablet, computer) being used to access the PROACTIVE app is beyond the scope of the app design, certain elements that would ensure low physical effort, or size and space for use such as having a lightweight device, are inapplicable here.

Challenges with Certain MoSCoW Requirements

Most of the requirements identified by the participants in the workshop were implemented in the app redesign. However, a few proved to be more complicated. These are: a search button, a colour blind compatible map, translation and an easy read option.

The first two requirements listed have been hampered from a technological perspective. Adding a search button is more complex than originally thought and the app developers are still working on this aspect. A search button for both incidents and information materials are likely to be included in a future iteration of the app. For the map, the app currently uses an already existing map service to plot the incidents. It is beyond the scope of PROACTIVE to develop its own map. However, news has reached us that the third party map service intends to release a colour blind friendly map soon. As soon as it has, this will be integrated into the PROACTIVE app.

Considering the requirement *translation*, the authors reviewed freely available translation technologies (e.g., Google translate). Unfortunately, these are not compliant with the European General Data Protection Regulation (GDPR) and other privacy by design concepts. Instead, the app will be manually translated from English into the languages used in the countries where PROACTIVE will run field exercises. These are: German, Italian and Dutch.

Providing an easy read option for the app is extremely relevant for disaster apps. Not only does this help persons with intellectual disabilities, have a low learning level and/or are deaf, but it would also be helpful for those suffering from situational disabilities during a CBRNe incident. The organisation Inclusion Europe recommends that any easy read document be co-created with persons with intellectual disabilities (Inclusion Europe, n.d.) in line with the idea of *nothing for us, without us*. Therefore, to create an easy read option of the information on the app, a new series of workshops would need to be organised with civil society organisations representing persons with intellectual disabilities. This was not able to be done in the scope of this app redesign.

Rating

We used a quantitative rating score to assess the overall app usability and user feedback. An average score of 2.7 out of 5 stars may seem a less than satisfactory result. However, one should consider that the very first version of the app was still missing many of the accessibility features, and workshop participants were being guided through the use of an unfamiliar app in an online setting. Most participants experienced the app in their second language, without access to one-on-one or manual assistance and their collected feedback is what dictated the revised versions of the app. From this point of view it can be argued that participants saw a potential for improvement in the app, as proven by their constructive qualitative feedback. This quantitative rating score will be used in the future as a metric of the app improvement, and we expect that it will gradually improve with each iteration.

CONCLUSION

This article showed how the PROACTIVE project, based on the concept of Universal Design, is implementing a user co-creation and iterative process in order to develop a new, inclusive CBRNe disaster app usable by all citizens, including vulnerable groups. Through four workshops, the prototype app was tested by end-users and a second set of end-user requirements was collected using the MoSCoW methodology. Co-creation has allowed for the app to consider 4 out of the 7 Universal Design principles. For the remaining three, solutions were also proposed.

The updated PROACTIVE app was shared and was able to take into account many of the requirements. The app has many new accessibility features, including audio information, text-to-speech compatible, high contrast ratios, larger buttons/icons/symbols, less text, basic working, and larger font size. Further, the authors believe, thanks to the feedback from the workshop participants, that the interface is now more straightforward and ergonomic. The co-creation process has ensured that vulnerable citizens' needs and expectations are met.

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Going forward, this new version of the app will be further tested, starting a new research cycle. These new tests will take place during field exercises, which replace the interactive play part of the workshops presented here. When the project is completed, the PROACTIVE CBRNe app is expected to fill the gap in a lack of citizen oriented CBRNe disaster apps available on the market today. It will also provide the opportunity to minimise the wider "accessibility gap" in emergency management.

ACKNOWLEDGMENTS

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CoRe Paper – Usability and Universal Design of ICT for Emergency Management
Proceedings of the 19th ISCRAM Conference – Tarbes, France May 2022

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