Research Update – Using SARA app and video feedback for dispatchers to improve the out-of-hospital cardiac arrest handling

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Abstract

Survival of out-of-hospital cardiac arrest (OHCA) is significantly improved by using an external defibrillator and performing cardiopulmonary resuscitation within the first minutes of the arrest (Perkins, Handley, et al., 2015). Dedicated mobile applications enable any bystander of an emergency to report it or to be called to perform first aid on victims (Ciravegna et al., 2016; Garcia et al., 2015). This paper presents the SARA app, which allows call centres to guide the person calling to enact first aid gestures through video. However, even if rescue community recognize the primary role played by citizens in emergencies by the rescue community, barriers still exist to an optimal collaboration. Citizens expressed a fear of hurting the victim and the health professional are reluctant to rely on non-expert. We also have to measure the usability of the app and evaluate the pertinence of video guidance.

Keywords: *Cardiac arrest, apps, community engagement, collaboration, Living-Lab*

On July 3, 2020, a new legislation was published in France aiming to create the status of citizen rescuer, to fight cardiac arrest and to raise awareness of life-saving gestures. The status of citizen rescuer is defined as follows: “Anyone who provides voluntary assistance to a person in an apparent situation of serious and imminent danger is a citizen rescuer and benefits from the quality of occasional collaborator of the public service” (Legifrance, 2020, p.14). The law stipulates, “The citizen rescuer performs, until the arrival of the emergency services, the first aid gestures by, if necessary, the implementation of chest compressions, associated or not with the use of an automated external defibrillator”. It is also specified “When a prejudice results from their intervention, the citizen rescuer is exonerated from any civil responsibility, except in case of heavy or intentional fault on their part”. The following headings emphasize the necessity to reinforce emergency training and to clarify the appropriate organizations to provide this training. The enactment of this law reflects the ongoing concern about a major public health issue: out-of-hospital cardiac arrest survival. This concern is shared by rescue professionals who are trying to provide technological and organizational responses, like the numerous regional initiatives that can be witnessed at professional events. It is also the concern of other more distant partners, companies, IT developers, and applications designers, who are putting their skills into this cause and designing new applications, intended to respond to emergencies with more efficiency. Among others, we can mention the "tech and rescue" events launched by an association of firefighters since 2019 which gives the opportunity to Departmental Fire and Rescue Services (SDIS) and promoters of technological solutions to present at a national level some local technological solutions, field-tested, aiming at improving the conditions of emergency handling.

Thus, there is national and public health interest in improving the management of cardiac arrest, combined with the emergence of technology solutions from collaboration between developers and first responders. In this context, we present a dedicated mobile app, SARA, developed and implemented by a first responder. Our research aims to analyze the conditions and limitations related to the use of SARA and ultimately its effect on cardiac arrest management improvement. First, the current state of the art on the necessity of rapid management of cardiac arrest will be presented, followed by a review of the obstacles associated with the management of cardiac arrest by non-expert citizens, and finally the technological solutions available to address the cardiac arrest issue. The second section of the paper presents the SARA application, its main specifications and its innovative features. Finally, there will be a discussion regarding the restrictions we have identified on the application's use (usability, mistrust of professionals towards citizens, citizens' fear of wrongdoing) and how to address them.

State Of The Art

The need for rapid intervention on cardiac arrest

Out-of-hospital cardiac arrest is still currently an important cause of death. The survival rate of patients in Europe and the United States varies between 7 and 10% according to studies (Gräsner et al., 2020; Rumsfeld et al., 2016; Berdowski et al., 2010). Two factors increase the survival rate: cardiopulmonary resuscitation (CPR) and the use of an external defibrillator (AED) (Perkins, Handley, et al., 2015). The time of action is particularly decisive as the probability of survival decreases within minutes spent without CPR (Herlitz, Svensson, et al., 2005; Herlitz, Engdahl, et al., 2005; Capucci et al., 2002). However, only 32% of cardiac arrest victims receive CPR from bystanders and 2% receive defibrillation (Weisfeldt et al., 2011). In this context, the question of increasing the chances of survival by actively involving bystanders in providing cardiac massage is central.

Engaging untrained citizens

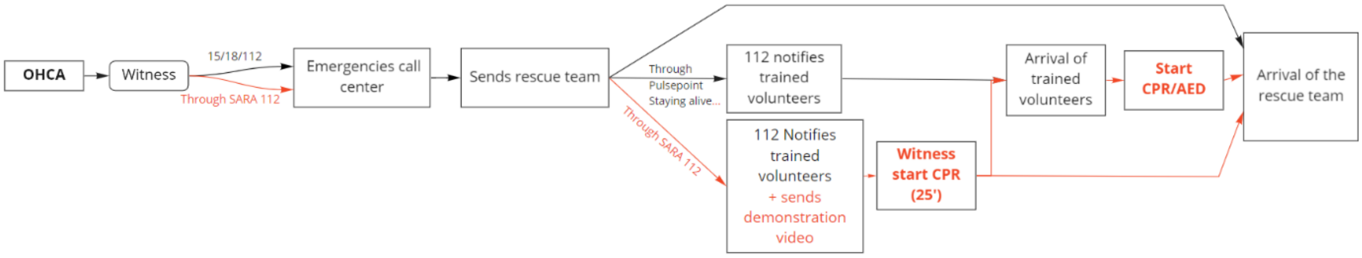
While the participation of bystanders is recognized as an essential factor in the survival chain, they are considered as the first actor in the rescue chain when dealing with a cardiac arrest, there are nevertheless impediments on the professionals and citizens side (Reuter et al., 2013). According to studies, untrained volunteers appear to some first responders to be more of a burden than a help (Scanlon et al., 2014). The issue is a lack of prior experience (Bird et al., 2020) and knowledge (McLennan et al., 2016). Indeed, in France, the rate of people trained in first aid is quite low, less than 20% according to the Ministry of Health's March 26, 2018 release . In contrast, in Switzerland, all licensed drivers have undergone mandatory training in first aid. As a matter of fact, the fear of performing CPR incorrectly is a major barrier for the citizen (Bouland et al., 2017; Kanstad et al., 2011; Dami et al., 2010), even when the population is widely trained like in Switzerland, where Basic Life Support course are mandatory to obtain a driving license (Regard et al., 2020). Some authors mention a lack of communication between both communities, which leads to misunderstandings and frustrations on both sides when the urgency of the situation requires quick and efficient communication (Reuter et al., 2016). Yet, collaboration between stakeholders in the response to crises or emergency situations is crucial (Kropczynski et al., 2018).

Mobile applications as a resource for first responders

Among the solutions provided by professionals themselves and the network of innovative actors in the world of civil protection in Europe, mobile applications have become part of the current panel of tools. One solution is to increase the number of trained volunteers available to respond to the situation. In this perspective, the use of mobile applications to call trained citizens seems to be efficient. Several international guidelines have already included this approach in their recommendations (Kronick et al., 2015; Perkins, Travers, et al., 2015; Rumsfeld et al., 2016). A review of various mobile apps conducted on Google Play, identifies 250 emergency-related apps (Gómez et al., 2013). 50.8% of the applications[1] concern a request for help related to a health problem (iSOS for example) followed by applications providing instructions to solve a certain emergency (42.4%) then 23.2% relate to a police help demand (Emergency Panic Button, SOSbeacon, Mayday Emergency Lite). Furthermore, the final user of the application is for 59% the victim, the professional rescue team (14%), volunteer rescuers (14%), witnesses (7%) and finally general public (6%). Most applications require access to 3 elements, location (81.2%), connection (bluetooth, internet access) and the use of communication tools (SMS, calls). The authors note that few applications focus on the potential of bystanders as witnesses or volunteers. They conclude their paper by expressing the necessity of an innovative application for 911/112 that could connect citizens and emergency control centres. Indeed, various mobile applications have been developed to notify first aid trained volunteers in the surroundings of an emergency. For cardiac arrests handling, we can mention Pulsepoint (Brooks et al., 2016), Save-a-life and Staying alive (Derkenne et al., 2020). The latter has enabled to increase the survival rate of victims from 16% to 35% thanks to a faster intervention (the first helpers notified are within a maximum radius of 500m from the victim). Therefore, it seems relevant to attempt to initiate CPR by the people closest to the victim. In fact, some developers have chosen to create applications where not only people trained in first aid are considered as potential rescuers, but any citizen

1 A given application can belong to one or more identified groups.

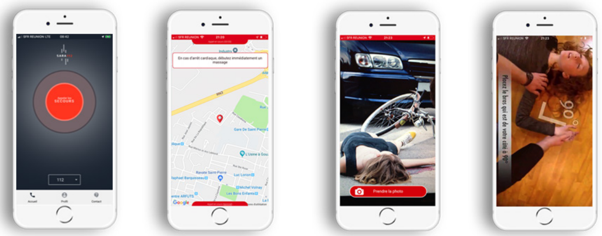
Figure 1.
Segments of actions in emergencies related apps



present at the time of the emergency such as SARA, the application described in this retsearch (Ciravegna et al., 2016; Garcia et al., 2015; Mazumdar et al., 2015; Díaz et al., 2013).

As can be seen in Figure 1, SARA allows an intervention in a currently unexploited segment. The bystander can call the emergency services via the emergency numbers or via SARA. The emergency services can dispatch a rescue team, activate an application with trained citizens who will arrive before the emergency services and send a demonstration video via SARA in order to initiate the cardiac massage with the bystander.

Figure 2.
SARA app



The Sara Application

Product description

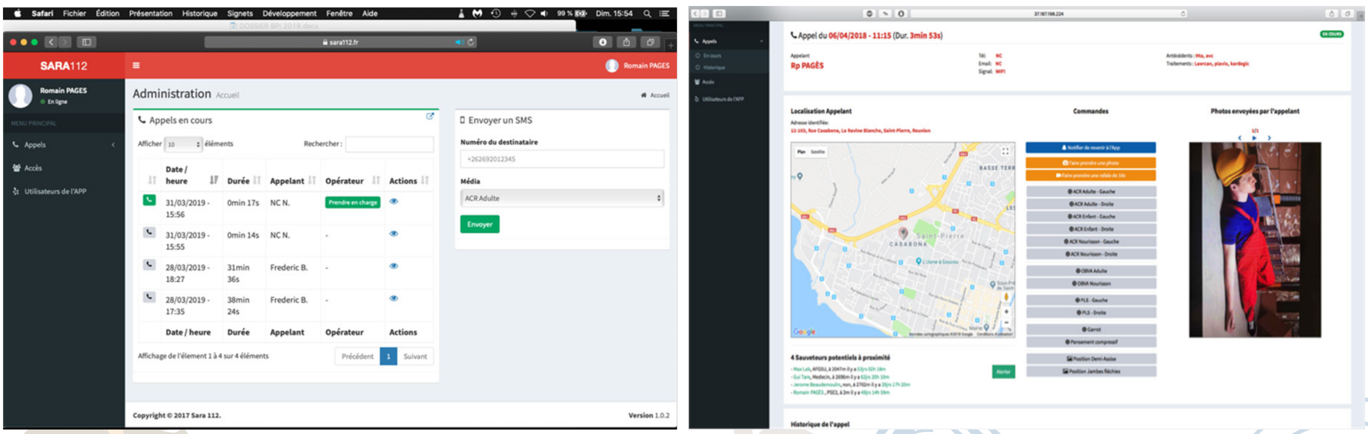
SARA is an application developed since 2017. The prototype version is currently available on iPhone and Android, on a prototype version and is not implemented in any dispatch call centre. It allows any citizen witnessing an emergency to connect with a regulation centre by calling 112 or any emergencies number. While remaining on the caller's line, the dispatcher can then:

- Identify the caller and know his medical history and treatments.
- Geo-locate the person.
- Ask the caller to take photos or videos of the emergency.
- Call for reinforcements from first aid certified personnel in the area.
- Trigger the video of the emergency actions to perform (e.g. cardiac massage).

Two elements are required for SARA to be functional. The application must be downloaded on the citizen's mobile (Figure 2), and the back office must be installed in the call centre to receive and control the application (Figure 3).

SARA is also a platform that offers 3 distinct solutions:

Figure 3.
SARA Back-office



- **SARA General public**; this solution includes all the features described above. It can be used by any person trained or not in first aid and by any emergency services (EMS, fire brigade). The objective is to propose a solution for everyone with a strong impact on the survival rate of victims and regarding the cardiac arrest response.
- **SARA Event**; This solution is based on the technological foundation of the general public version. It is intended for event organizers (trail, Olympic Games, festival, etc.). It allows a call to a dedicated number chosen by the organization. This app considers all the emergency teams in the field, by providing them with a dedicated mobile application that integrates the tools necessary for the optimal management of a victim (an assessment form, for example). The integration of connected objects (blood pressure meter, oximeter...) allows an implementation of the data. The transfer of the assessment to the referring medical service is also faster.
- **SARA Enterprise**: for SMEs, it allows in addition to the general public version, to alert (SMS, notification, email), a first-aid worker of the company as soon as the call to the emergency services is initiated. The App allows the simultaneous transmission of a potential work accident to the company's dedicated back-office. The system also enables the integration of a company or site map and the addition of data (access points, defibrillators, specific risks, etc.).

We will develop furthermore two innovations implemented in SARA; the demonstration videos in the application which aims at an efficiency and a speed of intervention and the interaction between bystander and dispatcher in case of cardiac arrest.

Table 1.
Demonstration videos

	Audio messages	Duration	Illustration
Cardiac arrest (Adult)	*Instructions* If there is a defibrillator nearby, ask someone to get it. Place the victim's arm at a 90° angle. Position yourself astride the victim as shown in the video. Place your hands on top of each other between the two breasts. Keep your arms straight and press as hard as you can. Follow the rhythm. Press with the heel of your hand. *Incentives* You are effective, relax the chest completely. You are doing very well, help is on the way, keep going. Good job, keep up the pace. Don't stop massaging.	24" seconds before starting CPR. 2'30 loop on cardiac massage	
Total Airway Obstruction (Infant)	*Instructions* Check the child's mouth and remove any foreign objects. If possible, sit and hold the infant as shown in the picture. Place the infant flat on your arm, resting on your leg. With the heel of your hand, tap vigorously up to 5 times. Turn the infant over and check that the mouth is empty. Place 2 fingers in the middle of the chest between the two breasts, on the line of the 2 nipples. Compress the breast and repeat 5 times maximum. Repeat the manipulation.	41" loop	
Lateral Safety Position	*Instructions* If necessary, remove the victim's glasses. Place the arm that is on your side at 90°. Grab his other arm and press it against his cheek. Raise the opposite knee, press it down to turn the victim. Gently remove your hand from the victim's face. Place his knee at 90°. Open the victim's mouth with one finger. Watch the victim.	48"	
Pressure bandage	*Instructions* Take a cloth, t-shirt, scarf or other fabric. Fold the cloth to fit the size of the wound. Place it directly over the wound to cover it. Compress the wound firmly. The other hand wraps the cloth around the limb. Tie a tight knot, preferably over the wound. Tie a second stopper knot to prevent the dressing from coming undone. Monitor the victim's condition, and if anything changes, call for help.	44"	

Demonstration Videos

When a citizen calls via the SARA application, the dispatcher can assess the situation and decide to send him a demonstration video to be viewed on his smartphone to assist him in the emergency gestures. The video is then displayed on the user's screen while the audio instructions are played over the call. The Table 1 shows the different videos with duration and instruction.

Overall, there are eight videos. Three on cardiac resuscitation (adult, child, infant) lasting 2 minutes 30 seconds in a loop after a start of resuscitation at 24 seconds for the adult, 2 minutes in a loop for the child after a start of resuscitation at 24 seconds and insufflations every 20 seconds and 1 minute in a loop for the infant after a start of resuscitation at 18 seconds and insufflations every 15 seconds. There are two 40 seconds loop videos on total airway obstruction (adult and infant) with demonstration of two techniques; back bow and Heimleich maneuver for the adult and back bow and chest compressions for the infant. There is also a 48 seconds video on the lateral safety position, a video on applying a garrot (1 minute 40 seconds) and a video on pressure bandaging (44 seconds). We can note that only the resuscitation videos include supportive messages such as "Help is on the way. That's very good, keep going, don't stop". The dispatcher can also display two pictures, the semi-seated position and the bent leg position.

Users' journey for cardiac arrest

As we can see in Figure 4, the interaction originates from the discovery by a bystander of a cardiac arrest victim. He must take his smartphone, open the SARA application, and then press "call for help", the application will open the call application with the number 112, 18, 15 ready to call. On the back-office side, the dispatcher operator receives a call request and takes it. This gives him access to the location, the information's, and the type of connection (Wi-Fi or data) of the caller – allowing to adapt the quality of the videos. The caller will then describe the situation and the operator may request to take a picture to understand the situation. The command will then be displayed directly on the caller's screen "take a picture". The dispatcher can then send a video demonstration of the cardiac massage that will be displayed on the screen of the Smartphone while the instructions are given through the audio. The bystander start CPR after watching 25 seconds of the demonstration video and continues until the arrival of the rescue team.

Concerns To Address Regarding The Use Of Sara

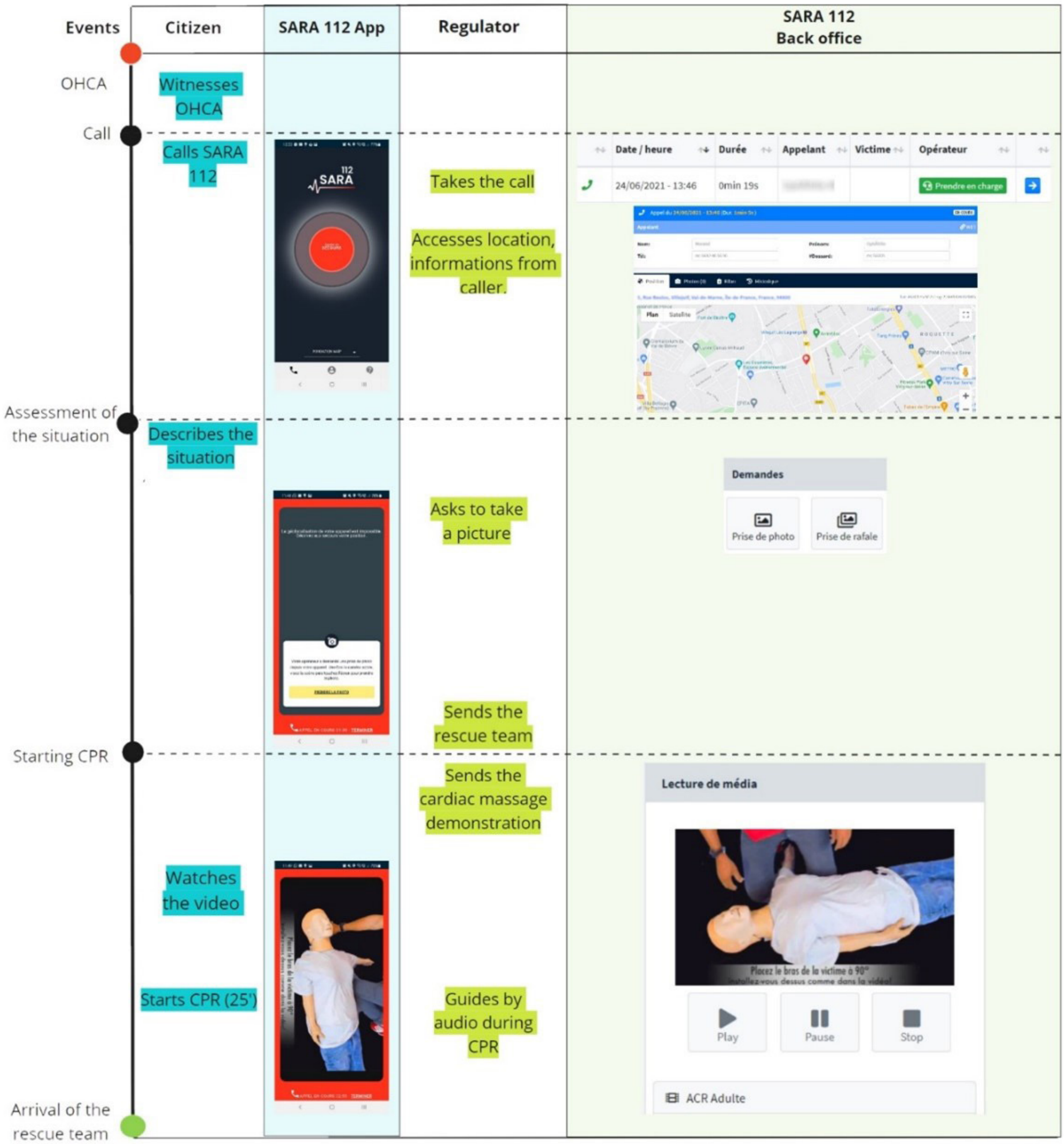
Collaboration between citizens and first responders

As discussed in our state of the art, one of the first concerns about SARA is the non-expert status of the citizens. We are facing the same problems as those mentioned in the literature: lack of trust of professionals towards non-expert citizens due to their lack of knowledge of rescue procedures and gestures, and fear of acting for citizens. The literature argues that mediated interaction through an application for example, has the consequence of deteriorating the quality of communication which can lead to a decline in trust between different parties (Riegelsberger, 2005). Nevertheless, the contribution of an application that allows several forms of communication; audio, photo, video can enrich the interaction and provide "evidence to build trust" can be beneficial. Effective communication and collaboration come from pre-established trust between the parties (Foulquier & Caron, 2010). During the handling of an emergency, the usual parameters for building trust are altered; time pressure does not allow trust to be built over a long period of time (Tehrani, 2020), it requires communities and individuals to collaborate when they usually don't work together (Boin, 2009). These observations can be the biggest obstacles to an efficient collaboration; therefore, we think that establishing a setting where the discussion and the sharing of a common experience based on the application can be a lever for further collaboration.

Video guidance in emergency situations

A major innovation of SARA is the possibility to trigger videos to help the bystander to perform the appropriate first aid procedures. A study has been conducted to assess the video guidance effectiveness compared to audio guidance in providing CPR by non-expert (Lesaffre, 2014). The study consisted of a simulation using an inanimate person (mannequin) for which the participants had to perform CPR. There were two groups; a group making a simple call for emergency assistance (control group) and a group watching the tutorial video prepared for the occasion after calling for emergency assistance. The findings indicate that participants of the video group carry out on average more compression than did the audio group. The time to start CPR is longer for video guidance but once started, there are less interruptions in compressions. The mannequin sensor showed a difference in favor of the video group with 96.5% of compressions well positioned 95.9% compared to the

Figure 4.
Example of users' journey with SARA in case of cardiac arrest



audio group ($p < 0.05$). This data suggests that cardiac arrest bystanders can be guided by video on a cell phone without compromising the quality of cardiac massage and may even improve it. Some parameters can be enhanced such as frequency, number and duration of interruptions, hand position, total number of compressions and proportion of effective compressions. However, there was no significant difference between the video group and the audio group on the primary endpoint: the number of effective compressions in six minutes. This finding should be moderated since other studies have shown that viewing tutorial videos do increase the quality of assistance provided by non-experts (Stipulante et al., 2016; Bobrow et al., 2011; Yang et al., 2008, 2009; Johnsen & Bolle, 2008).

The application is also being tested in the Geneva hospital (HUG). The test continues the investigation of the efficiency of video assistance compared to audio guidance in case of an emergency. The results will be the subject of a medical thesis. The first feedbacks are positive regarding the quality of the gestures performed, the physician associated with the project specifies " I was able to see at the level of compression rate and depth that the people guided by video were clearly better. They took a little longer to start CPR, but the quality was incomparable”. Although studies have shown the effectiveness of using videos for guidance, the results published (Lesaffre, 2014) do not show significant results in terms of compression numbers. In addition, other demonstration videos (total airway obstruction, compression bandage, lateral safety position) are available and their effectiveness has not been evaluated. In case of chocking, the first minutes are crucial as is it is for out of hospital cardiac arrest. Case reports showed success in relieving Foreign Body Airway Obstruction (FBAO) with back blows, abdominal thrusts and chest thrusts (International Liaison Committee on Resuscitation, 2005). The recommendation adds that more than one technique is often needed to success. The demonstration video shows 2 techniques: back blows and abdominal trusts under 1 minute that can be performed simultaneously with the viewing of the video. It would therefore be interesting to evaluate whether these videos help bystanders perform maneuvers faster or more efficiently. The application also allows the dispatcher to access the camera of the citizen present at the scene. So far, no study has been done to evaluate the possibilities of this implementation from the point of view of the dispatcher. If the aim is to create collaboration between the citizen and the dispatcher, it would be interesting to highlight the benefits that the operators can obtain themselves. We think for example of the evaluation of a stroke. Stroke has been classified as the second most important cause of death in the world, with an estimated annual death rate of 5.5 million and 50% of the survivors have chronic residual disabilities (Lopez et al., 2006). One of the causes of delay in stroke management is the lack of recognition of early warning signs in the general population (Donkor, 2018). Indeed, studies show that less than 50% of people know the risk factors and recognize the warning signs of stroke (Cossi et al., 2012; Hickey et al., 2009; Yoon et al., 2001). Consequently, it might be beneficial for an expert not present on the scene to be able to assess the situation remotely and take action at the earliest stage possible.

Usability of the application

One other point to consider is the usability of the interface. Usability is defined as follows: ‘The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use’ (International Organization for Standardization, 2018). If the application is not perceived as "usable" by users then chances are it will be abandoned as are 1/4 of the applications on the market (Tan et al., 2018). Usability is linked to 6 factors (Hoehle & Venkatesh, 2015); app design, app utility, user interface graphics, UI input (the degree to which users perceive that app allows easy input for users), UI output (the degree to which users perceive the app displays information effectively) and UI structure (degree to which users perceive the app is structured well). These factors are associated with “continuance intention," the willingness to persist in using the application after the first experience (Tarute et al., 2017; Hoehle & Venkatesh, 2015) or intention of use (Venkatesh et al., 2003; Venkatesh & Bala, 2013). A study on disaster apps shows that the utility of the application is the first determinant of usage followed by UI output, which must be particularly easy to understand in critical and stressful situations (Tan et al., 2018). The United Nations Office for Diaster Risk Reduction insist on the fact that it is imperative to improve the usability of such services providing information in a clear and concise way (Mentler et al., 2017). Moreover, the study shows that UI input and UI graphic have a negative effect on the intention of use. Therefore, the authors recommend the simplest and most sober interface possible. To achieve acceptance of SARA by the public and by emergency responders, we have to evaluate its usability with the aim of implementing appropriate modifications if needed.

Data collection and privacy

The collection and responsibility of the data collected by the app may also become an issue. Indeed, the user is providing the application personal data about himself: his medical history and his location (McCarthy, 2013). SARA is a private application and therefore must comply with the personal data processing regulations according to the law General Data Protection Regulation (2018). The law does however provide for an exemption from confidentiality within the context of vital emergencies treatments. It is therefore necessary to determine at which category the application belongs to, considering the range of interventions that it addresses.

Further Development Of The Project

To address the issue of the usability itself, a questionnaire will be used. It was built from items developed in the UTAUT 2 (Unified Theory Of Acceptance and Use of Technology, (Venkatesh et al., 2012) along with items from the User Experience model (Hassenzahl, 2007) and validated (Martin, 2018). It allows evaluating a technology before and after use on 6 dimensions influencing the intention to use.

The others concerns mentioned in the previous section led us to seek a methodology that would allow us to test and evaluate the functionalities of SARA while bringing together all stakeholders. Conducting tests in real-life situations seems rather difficult, first because by doing so we could disturb practitioners and compromise their actual work (Leitner et al., 2007). It can also raise concerns about the user and researcher safety. On the opposite, a laboratory experimentation seems to be overly distant from reality since all variables are under control and there isn't any possibility of uncertainty (Mentler et al., 2017). Some variables cannot be replicated in the laboratory (stress, for example). Therefore, several authors suggest using simulations or future use scenarios to reproduce emergency situations (Gerhold et al., 2020; Mentler et al., 2017) which enable experimentation in a semi-realistic context (Gerhold et al., 2020; Borglund & Öberg, 2014; Yao et al., 2010). Scenarios can preserve the richness and complexity of a given situation and allow it to be experienced in an embodied way (Gerhold et al., 2020; Martin et al., 2017). Conducting simulated real-life experiences enables users to manipulate and gain a sense of activity (Daniellou, 2004) and thus develop pertinent responses and knowledge for these situations. We also aim to develop collaboration between stakeholders in an environment that is conducive to collaboration. Simulation with usage scenario has been tested in Living-Labs in emergency field (Derkenne et al., 2020; Gerhold et al., 2020; Munkvold, 2016) and have shown benefits (knowledge transfer through the creation of a common discourse for example). This methodology has been defined as "physical regions or virtual realities in which stakeholders form public-private-people partnerships of firms, public agencies, universities, institutes, and users all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts" (Leminen et al., 2012, p. 7). Stakeholders are invited to test the actual product. In this way, questions about the technologies, their benefits and potential negative effects arise and can be discussed at once while enabling all attendees to learn from each other (Gerhold et al., 2020).

Conclusion

The SARA application meets many needs; inclusion of citizens as an entry point in the emergency chain (Gómez et al., 2013), getting volunteers to perform cardiac massage (Weisfeldt et al., 2011) and potentially more effective guidance through demonstration videos (Lesaffre, 2014; Yao et al., 2010). Its use nevertheless raises many questions regarding the involvement of non-expert citizens, the improvement of collaboration between professionals and bystanders and the actual usability of the application. All these questions require answers if this application intends to be disseminated, as it appears quite promising to improve the chances of survival of cardiac arrest victims.

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Conflicts of Interest

The authors reported no potential conflict of interest.

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