Identifying functions for smartphone based applications in volunteer emergency response

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ABSTRACT

Emergency response organisations struggle with resource constraints and thereby faces challenges in providing high-quality public services. Utilising voluntary first responders is one way to address these challenges. There are different types of volunteers who can help at an emergency site, e.g. citizen volunteers or voluntary professionals from other occupations. To successfully engage with and utilise these resources, adequate information and communication technology (ICT) is necessary. In this meta-study, combining and further exploring two previous studies, the aim is to identify, analyse and evaluate suitable functions for smartphone applications that can be used to dispatch and support volunteers. The results show that the functions can be divided into essential ones that are necessary for the response to work at all, and others that might contribute to a more effective response. The study also shows that the same functions can be used for different volunteer groups.

Keywords

Voluntary emergency response, ICT, smartphone application, end users, co-production.

INTRODUCTION

In many countries, high public demand and decreased budgets make it difficult to maintain proper service levels for emergency response. In rural areas, professional first responders are supposed to serve geographically large jurisdictions, while in urban areas few responders often serve large populations. When distances become longer, and available rescue personnel are scarce, nearby volunteers might be dispatched to emergencies to provide assistance before professional responders arrive, potentially saving lives and mitigating damage. Previous research has highlighted the need for more studies concerning onsite volunteers (Schmidt et al., 2018) and pre-planned and long-term collaborations with professional emergency response (Diaz et al., 2016; Johansson et al., 2018).

Two emerging types of pre-planned and onsite volunteers as first responders are citizen volunteers and semi-professional volunteers, who respond to local accidents or medical incidents in collaboration with the professional emergency services (police, fire, emergency medical services). Citizen volunteers can be neighbours helping each other in their village or residential area. Thus, they have no formal organisational affiliation (Jaeger et al., 2007; Linders, 2012; Venema et al., 2010; Whittaker et al., 2015). Voluntary semi-professionals on the other hand are employed, or paid, by some level of government (typically local, e.g. municipal) to take on additional tasks in emergency response (SOU, 2018). Thus, they have their regular full-time employment and add on the new responsibility as a first responder (Sund and Jaldell, 2018; Venema et al., 2010). Semi-professionals can be seen as a kind of volunteers, just like citizen volunteers. Even though they perform their new tasks as part of their employment, in most cases it is not mandatory to accept the new duties and it is always up to themselves if they want to respond to an emergency or not. These two emerging types of

volunteering can be viewed as co-production of public services (Alford, 2014; Ostrom, 2016). Volunteering have also been referred to as "do-it-yourself government" as an emerging culture within public services (Linders, 2012; Venema et al., 2010). Although co-production seldom focuses on the information and communication technology (ICT) artefact, current public-sector trends all have modern ICT as an enabler. However, the existing infrastructure for emergency dispatch (e.g. radio) is often not convenient or available to voluntary first responders (due to e.g. organisational hindrances and legal obstacles) (Ramsell et al., 2017). Therefore, new ICT solutions become necessary in order to coordinate their emergency response work with professional first responders.

Many initiatives utilising the new resources have opted to use smartphone-based solutions (e.g. Gomez and Murray Turof, 2007; Ringh et al., 2011). However, studies have shown that developing and using these includes a number of unsolved challenges, e.g. identifying suitable functions based on end-user needs (Havlik et al., 2016; Roberts et al., 2014; Schönböck et al., 2016). This perceived knowledge gap is addressed in this study. In addition, earlier studies (Mojir et al., 2018; Ramsell et al., 2017) indicate that basic needs for such resources, such as training and equipment, are often similar for different voluntary groups, but research to establish whether this is also true for the specific ICT artefact is needed.

Study Aim

The aim of this study is to:

- Identify and evaluate suitable functions of an ICT artefact in the form of a smartphone application, based on end-user involvement (the volunteers).
- Explore whether the same ICT functions, can be used for different volunteer groups.

The study is a meta-analysis, built on two previous case studies analysing and identifying both general needs and ICT needs of two different volunteer groups: citizen volunteers and semi-professional volunteers. Both take place in the context of Swedish emergency response. However, since many basic tasks in first response are similar at an international scale, the results are also discussed in a wider emergency response context. For instance, the existing research on specific platforms and applications for volunteers in disaster management (e.g. de Lanerolle et al., 2010; Schmidt et al., 2018) may benefit from this study's contributions.

THEORETICHAL CONTEXT: CO-PRODUCTION AND USING VOLUNTEERS AS FIRST RESPONDERS

Voluntary engagement that is informal yet conducted in collaboration with professional response is described using different terms in the literature. For instance, Whittaker et al. (2015) highlight "spontaneous organisation volunteers", Diaz et al. (2016) use the concept of "citizens as agents", and St. Denis and Hughes (2018) report on an online application used with "trusted volunteers" of emergent community groups. Thus, to define the two voluntary groups in this study – citizen volunteers and semi-professional volunteers – we use a broad definition: "volunteerism refers to the activities of people who work outside of formal emergency and disaster management arrangements to help others who are at risk or are affected by emergencies and disasters" (Whittaker et al., 2015:361).

At a societal level, it is possible to see a shift in public service delivery, and emergency response specifically, where communities, citizens and other professions are increasingly involved in first response. Here, the exchange of resources, non-hierarchical patterns and social relations are some of the keywords among different types of actors united in the common endeavour of providing more effective and flexible public services (Agranoff and McGuire, 2010; Börzel, 1998). These kinds of collaborations are usually described by network concepts such as collective action (e.g. Carlsson, 2000), collaborative networks (e.g. Agranoff, 2006) and network governance (e.g. Loukis, 2016). A common denominator is the necessity of ICT in the networks, whereby ICT "helps connect various actors to the network, build relationships between them, […] and manage[s] and sustain[s] the networks themselves" (Janowski et al., 2012:52).

Building on the network context, the concept of ***co-production*** can be used to more specifically describe different actors' involvement in public-service delivery, e.g. volunteers. With digitalisation, the possibilities to co-produce have increased (Linders, 2012). For instance, nowadays almost everybody has a smartphone that can be used for advanced information exchange and coordination. According to the definition, co-production is "the process through which inputs used to produce a good or service are contributed by individuals who are not 'in' the same organization" (Ostrom 1996: 1073). Alford (2014) mentions one example of co-production in which a Fire and Emergency Services organisation expanded the role of residents to include performing different preventive tasks aimed at protecting "life, property and the environment" (Alford, 2014:302).

In this study, ***ICT-facilitated co-production*** is used as a concept to describe volunteers' involvement in emergency response. Specifically, two different types of voluntary co-production initiatives are in focus. ***Semi-professional volunteers*** refers to persons who, as part of their professional work, volunteer to act as first responders. ***Citizen volunteers*** refers to citizens taking over certain tasks from the authorities for themselves and their co-citizens, creating a "do-it-yourself government" (Brandsen et al., 2018; Diaz et al., 2016; Linders, 2012). While volunteer engagement has been studied using various network perspectives from different research disciplines – including co-production – the perspectives have in common that they seldom focus on the ICT artefacts, but rather on politics, policies, values, economic and welfare aspects. (Agranoff, 2006; Carlsson, 2000; Janowski et al., 2012; Loukis, 2016). Regardless, the technology is a prerequisite for the phenomenon in the first place; if the ICT does not work adequately, volunteers cannot be dispatched to act as first responders.

Earlier research emphasizing the ICT artefact for volunteers in emergency and disaster response often focus directly on the technical solution and general evaluations of the solution, while the process by which it is reached is seldom explored in detail (e.g. Ferguson et al., 2016; Ringh et al., 2011). We have not managed to find earlier research where the users' perception is central, what their actual needs and requirements are. In some studies it is possible to receive information about identified functions even though this is not the core focus of the studies (see Table 1.). Thus, here we believe that our study can make a significant contribution. In order to enrich previous research, it focuses on the ICT artefact in a co-production context, and how it should be realised in order to be useful for various types of volunteers.

Table 1. Functions of ICT solutions (smart phones) for volunteers in disaster and emergency response

Functions	**Earlier studies**							
	Aufer-bauer and Ganhör, 2015	Berg-lund et al., 2018	Gomez and Murray Turof, 2007	Havlik et al., 2016	de Lan-erolle et al., 2010	Meissen et al., 2017	Schmidt et al., 2018	Schön-böck et al., 2016
Registration (app/online)	x					x		x
Personal profiles (skills/competencies)	x			x		x	x	x
Alert through SMS/app	x	x	x	x	x	x	x	x
Information (description of the incident/task)	x	x		x		x		x
Acknowledgement		x				x	x	x
Navigation/map	x	x		x		x	x	x
Bringing equipment								x
Communication possibility/two way communication				x	x			x
Send image, video, audio from incident	x							
Gamification/reward (to foster motivation)								x
Feedback/evaluation		x						x

METHODS

This study is a meta-analysis of two earlier case studies of volunteer engagement in emergency response (Mojir et al., 2018; Ramsell et al., 2017). The former took a broader perspective, encompassing the overall collaborations, including training, equipment, legal issues and also specific needs for ICT, but without a thorough analysis or evaluation of the functions of an ICT solution. Therefore, we now focus on the functions identified and implemented in a prototype smartphone application, and explore it in relation to the two voluntary groups, i.e. the semi-professionals and the citizen volunteers.

Study Context in the Separate Cases

The two previous studies here can be described as exploratory, referring to case studies that explore emerging phenomena (Flyvbjerg, 2006).

Case 1 was the development of the concept of ***semi-professional*** first responders in the municipality of Norrköping (a medium-sized municipality in south-east Sweden). The project ran from 2015 to 2017. The purpose of the project was to identify, analyse and evaluate potential first responders who could support the professional first responders, e.g. by extinguishing small fires or performing first aid. An additional purpose of the project was to identify their needs for training, equipment and ICT support. There was no existing organisation or infrastructure at project start. Therefore, a prototype smartphone application for semi-professional first responders was developed. Four different professional groups were analysed: security guards, home-care personnel, municipal facility service personnel and day personnel at the fire and rescue services (FRS). Finally, day personnel at the FRS were selected as voluntary first responders in the project. The day personnel are not part of the operative response organisation, but work with such aspects as logistics and the procurement of materials, information management, education and inspections.

Case 2 was an emerging collaboration, initialised by the FRS in the rural province of Medelpad which was first studied 2014-2015 and then 2017, where ***citizen volunteers*** were provided with training to enable them to perform first response to accidents and selected emergency medical cases in their own villages, such as fires, traffic accidents, drownings and cardiac arrest. Some volunteers were, or had been, working within the medical or rescue domain, while others had no previous experience. Many of the volunteers were retired, and others worked on farms or in sawmills. The selection criterion to start a voluntary group in a village was that the expected response time for the FRS should be at least 25 minutes. When there was an incident in one of the villages, all volunteers in the village were alerted by an SMS (short message service) on their private mobile phones through the Swedish PSAP (in Sweden this is SOS Alarm, which is responsible for answering the national emergency number 112, and also for dispatching some emergency response resources and coordinating different emergency response organisations). To find a more sophisticated ICT solution for the volunteers, with additional functions, the same prototype smartphone application as in Case 1 was adapted to the citizen volunteers' specific needs.

Data Collection

In both cases, a variety of methods were used to collect data, including semi-structured interviews, focus group interviews and future workshops. Throughout the data collection, end users have been the source of information and have participated actively. More detailed information concerning the data collection in each case is reported in Mojir et al. (2018) and Ramsell et al. (2017).

Prototype Development – a Smartphone Application

Based on the data collection for each case, specific ICT functions for the end users were identified for each voluntary group. To test how these functions could be implemented, and to analyse and evaluate them, a ***prototype smartphone application*** was developed. The reason why we developed a prototype instead of using an already existing application, e.g. Mobile Life Saver, MLS (Ringh et al. 2011) or a commercial application such as Safeland (safeland.se) was to gain a better experimental control for the study. A compilation of identified functions was conducted, and a selection was implemented in the prototype, based on which: a) were considered most important by the volunteers and b) were possible to implement and test.

The prototype are for smartphones running on the Android operating system. The primary function of the application is to be able to receive an alert. When this happens, the application notifies the user with a signal, and a notification on the lock screen and in the notification list. When the user has opened the application, brief information about the incident is presented, and the user can accept (green button) or decline (red button) to go (See Figure 1).

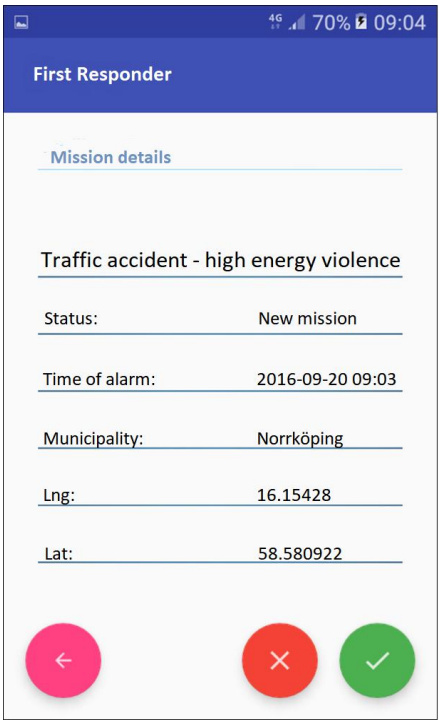

Figure 1. A new alert in the smartphone application

A first prototype was developed in Case 1, but partly based on results and learning outcomes from Case 2, where some user needs had already been collected. After using and testing the application in Case 1, the application was used in Case 2 with some additional functionality based on an additional data collection in the later phase of the study.

Tests of the functions and Evaluation

Four tests were conducted in which the smartphone application was tested by the volunteers/end users. Thereafter, the tested functions were evaluated and discussed by the users, who reflected on which functions seemed satisfying, which could be improved, and possible solutions. Since this study is a meta-analysis, the tests are not identical or designed to be comparable across the two cases, but they all have the overall aim of determining whether the functions fit the end users' needs.

Test 1 was performed over a time-span of two months. Nine potential ***semi-professional*** first responders in Case 1 were equipped with a smartphone with the application installed. Alerts were sent to the participants, who were supposed to indicate, whether they would have been able to accept the assignment, had it been a real case (they were not supposed to go to the incident site). During the test period, an online qualitative questionnaire was available where the participants could give feedback about the test and the application, and suggest new functionality.

Test 2 was performed with two of the ***semi-professional*** first responders from Case 1, who were dispatched to a simulated traffic accident with two injured victims. The responders were placed in their own cars and received the alert on the smartphone application. They went to the accident site and performed first aid until the arrival of the emergency medical services and the FRS. The test was observed and filmed, and was also evaluated in an After-Action-Review (AAR; Myers, 2009) with all participants (semi-professionals, FRS, ambulance services), where the application and its functionality were discussed.

Test 3 was performed with five ***citizen volunteers*** from Case 2 during two days. Before the test, the participants had to download and install the application onto their own Android-based smartphones. During the test, a set of alerts was sent to the participants, who could accept or decline according to their own preference. The aim was for them to become familiar with the application and its functions. About a week after the test, a group interview was held in which the application and its functions were evaluated.

Test 4 was also held with ***citizen volunteers*** from Case 2 and partly as a consequence of the low number of

participants in Test 3, as the requirements of having your own smartphone and being able to install an application were too high for many potential participants. Thus, this test was performed as a workshop with one moderator (researcher and first author of this paper) and with prepared smartphones that the participants could borrow. This resulted in 12 participants who, during the test, received alerts and tested and evaluated the application and its functions.

Meta-analysis

From the collected data, a comparative meta-analysis was conducted. First, we collected all functions which were identified in both cases. Secondly, we went through the functions once again to get a more detailed understanding and to compare them; e.g. if similar or the same functions were identified in both cases, and what differences there were. After this, we grouped the functions in a) all identified functions, b) functions identified in both cases and c) functions only identified in one of the cases. In group a) we also added the volunteers' perception of each function. Then, with help from the grouping, we summed up the analysis of the functions, i.e. which functions the users perceived were most important and if these were the same or not for both volunteer groups. Finally, to generalise the results and put them into context (i.e. co-production), we compared the identified functions with studies from the literature.

RESULTS

The results include the identified functions, as well as user feedback from the tests and evaluations.

Identified ICT Functions

From the two cases, 12 functions were identified by both of the two groups (see Table 2). One additional function, information to the employer (No. 6), was identified by the semi-professionals, but was not applicable to the citizen volunteers (because they have no employer in their role as first responders). In Table 1, the 13 identified functions are ordered according to how they would occur during a mission; with the non-mission-specific check in/check out function (No. 1) at the top, followed by the alert signal (No. 2), and ending with a function for leaving and receiving feedback (No. 13), which occurs after a finished mission. While some of the functions are self-explanatory, additional information is provided for the others below.

The ability to check in and check out (No. 1) is requested by responders who will sometimes not be able to accept a mission for some time (hours, days or weeks), but still want to remain a responder. The ability to see who else accepts an assignment (No. 5) was highly desired by citizen volunteers, while some of semi-professional volunteers stated that it should not matter who else responds; if you get the mission, you should go either way.

Information to the employer that the responder has deviated from normal duties (No. 6) was only relevant for semi-professional volunteers; even though it is possible that a citizen volunteer will leave their ordinary job to go on a first response alert, the responsibility for the regular work tasks left undone would remain with the volunteer. Comparing this to semi-professional volunteers, the responsibility would transfer to the employer, since semi-professionals are doing first response as a task within their current employment contract. By notifying the employer, it is possible to arrange substitutes, or just reschedule the abandoned task for later.

The ability to communicate that a volunteer should abort a mission (No. 8) was originally suggested by professional response personnel in discussion with volunteers, who also thought that this function would be useful. For instance, if volunteers have been dispatched to an incident, and new information indicates that the situation is dangerous (e.g. gunfire or toxic substances), there should exist some quick way of reaching the volunteers to tell them to stop and wait. Another abort signal, but from the volunteer responder side (No. 9), was also deemed useful. It should be possible for a voluntary responder to indicate that the mission will be aborted, if he/she cannot reach the incident site; e.g., due to car problems.

In terms of a checklist for the responders (No. 11), various ways of having the application support the work on site were discussed; for example, having specific written (or audio) instructions for different types of incidents, or connecting it to other existing applications (e.g. first-aid guides).

While it is technically easy to implement communication with professional responders or emergency call operators (No. 12), it is more complicated to determine who should be contacted. One obvious choice is just to add a button that enables a call to the national emergency number 112. Since the PSAP in Sweden is responsible for coordinating different emergency response resources, this makes sense. However, when calling 112, if the closest alarm centre is busy, the call is transferred to another centre, where the operators might not know about the new resources, and time might be lost if the volunteers have to explain their role in the response.

Feedback (No. 13) can be used for different purposes; firstly, when the voluntary responders want to share their experiences in order to facilitate learning and development. Secondly, it can also be used to initiate a dialogue, or request help with dealing with potentially traumatic experiences related to an emergency response.

Table 2. Identified functions by voluntary first responders

No.	Identified functions	by semi-prof. volunteers	by citizen volunteers
1	**Check in/check out**: The possibility to opt out of the role of responder for a limited time	x	x
2	**Loud and unique signal:** It has to be possible to hear an alert at all times, and it should not be mistaken for any other notification	x	x
3	**Information**: A brief description of the incident	x	x
4	**Acknowledgement**: The possibility to accept or decline a mission	x	x
5	**Other voluntary responders**: It is possible to see who else has accepted the mission	x	x
6	**Information to employer**: Automatic information to the employer that the responder has deviated from normal duties	x	Not applicable
7	**Navigation**: A map with the incident site marked, navigational instructions, voice navigation	x	x
8	**Abort**: Information if the mission needs to be aborted, due to a dangerous incident site, or if the responder is no longer needed	x	x
9	**Abort status**: The possibility to indicate that the mission has been aborted	x	x
10	**Arrival status**: The possibility to indicate arrival at the incident site	x	x
11	**Checklist**: Information supporting practical response, e.g. how to act in specific accidents	x	x
12	**Communication possibility**: A quick way to contact professional responders or emergency call operators	x	x
13	**Feedback**: The possibility to fill out a mission report	x	x

Test and Evaluation of Identified Functions

Nine of the identified functions were implemented in the prototype, and tested by the voluntary groups. Specifically, six functions were tested by both groups (see Table 3), and in addition, due to relevance and/or test limitations, two more functions were tested by citizen volunteers and one other function by semi-professional volunteers. For semi-professionals, the feedback function (No. 9) was only partly tested (in Test 1), where the only possible feedback was that the users could indicate why they had missed an alert. For the citizen volunteer tests, the volunteers could respond to a larger set of questions (in Tests 3 and 4).

Table 3. Functions implemented and tested in the smartphone application

No.	Function	Tested by semi-prof. volunteers	Tested by citizen volunteers
1	Check in/check out	x	*
2	Loud and unique signal	x	x
3	Information	x	x
4	Acknowledgement	x	x
5	Other voluntary responders	**	x
6	Navigation	x	x
7	Arrival status	x	x
8	Checklist	**	x
9	Feedback	Partly	x

**Not tested due to test limitations, **Not tested due to not being a priority for semi-professionals.*

Overall, the smartphone prototype functions satisfied the previously identified user needs – the responders received their alerts, acknowledged them, and followed the navigation system to the test incident site (physically or virtually, depending on the test).

The check in/check out function (No. 1) was only tested by the semi-professionals, who thought it was a good function to have since the application is running in the background, and it may not be sufficient just to turn it off. Both semi-professional volunteers and citizen volunteers commented that they missed alerts because they did not notice the signal or the vibration when their phone was in silent mode (No. 2). One semi-professional thought the vibration was too weak. Some citizen volunteers claimed that it was not loud enough and sounded like a regular notification. They emphasised that you need to be able to hear it even in noisy environments and when you do not have the phone right next to you; for example, by means of a blinking light, a stronger vibration and an even louder sound alert. In the AAR in Test 2, the semi-professionals stated that the amount of information about the incident (No. 3) was sufficient. Apart from complaints about the design of the application (confusing symbols and small text), no issues were reported for the acknowledgement function (No. 4). The ability to see who else accepts an assignment (No. 5) was greatly appreciated by citizen volunteers (in both Test 3 and Test 4).

In the application, if the user accepts the alert, an offer of navigational assistance is made; if accepted, Google Maps enabling navigation is launched (No. 6). The navigation aid is the same as in the existing solution for citizen volunteers (through a link in the SMS to Google Maps). Still, the citizen volunteers said that it was easier to access the map from the SMS, and that it should be possible to access the map in the application before the mission is accepted, as soon as the responders receive the incident information. The main reason for this is probably that their current system alerts everybody on the SMS list, and not only those who are actually close to the incident, as in the prototype application. There was also criticism of the navigation aid from the semi-professionals after Test 2, when one of the responders was doubtful whether he would have arrived at the right place if he had followed the instructions. Also, the possibility to indicate arrival at the incident site (No. 7) was forgotten by some volunteers – they did not remember to press the button.

The citizen volunteer responders stated that the checklist (No. 8) should be specific to each type of incident, and contain a limited amount of text. On the other hand, some citizen voluntary responders, as well as other semi-professional responders, said that they did not want to use any type of smartphone application at the emergency site, but needed to focus on the emergency work. Instead, they claimed that the checklist could be used as a preparatory tool, to remember what to do before an incident and during the travel to the incident site (if there was more than one responder travelling together).

Regarding the feedback function (No. 9), the citizen voluntary responders said that there were too many questions, and that the answers to some of them could easily be automated, e.g. arrival time. Also, they did not like the use of the word "debriefing" in the question: "Do you want debriefing?", and felt that this indicated that the responder might have psychological problems. It would be better to ask if they had identified any lessons that they would like to share or to have a routine to meet up for a cup of coffee after a response.

One of the citizen volunteer groups had already enhanced the SMS-based solution with additional smartphone applications; for example, by providing a loud and unique signal with flashing lights as well as GPS tracking and a position presentation for all responders. During Test 3, the citizen volunteers who were used to the enhanced SMS solution expressed negative opinions about the tested application and believed that it was difficult to use and not intuitive. The other citizen voluntary group in Test 4 (who had not developed additional

functionality) also said that the application was not user-friendly and that the button symbols were confusing, but at the same time they stated that the application, with its additional functionality, was a great improvement upon their current SMS solution. The semi-professionals were generally pleased and did not believe that they would have made much use of additional functionality in the application, but instead highlighted the value of training and education.

To sum up, the tests with citizen volunteers indicated that the two most important functions were the alert signal (No. 2) and the possibility to see who else is responding (No. 5). While an explicit ranking of the functions was never performed in the tests with semi-professionals, the ability to see who else responds was not highlighted as one of the more important functions. However, a loud and unique signal was also highlighted as crucial by the semi-professionals.

Evaluation: Identification of Additional Needs and Functions

The tests gave rise to new suggestions about needs and functions, which were discussed during the evaluation. The citizen volunteers also wanted to ***receive information about when professional responders will arrive*** (a similar function to No. 5 – to see who else has accepted an assignment). While the semi-professional responders agreed that it may be nice to know this, they did not rank it as vital information. One argument was that the incident in Test 2 took place in a city, where professional emergency services typically have a short response time. This may be compared to the citizen volunteers, who respond in a rural area involving long distances.

Another new need was to be able to ***see which equipment the responders are bringing***. Equipment that volunteers could be asked to bring to the incident site include automated external defibrillators (AEDs) and fire extinguishers. There were various ideas about how this need can be implemented as a function:

- Simple general information about what might be useful to bring to the specific type of incident.
- A status button, where the responder can indicate that he/she is bringing the equipment. This is particularly relevant for citizen volunteers, because some villages only have one AED; if somebody picks it up and indicates this, it might prevent others from losing time by going to get it as well instead of heading straight to the incident site.
- Assignment of equipment to responders, where the system decides which responder should bring each piece of necessary equipment, and informs responders of this through the application.

One of the semi-professional responders forgot to report his arrival in Test 2, giving rise to the suggestion that the application should be able to ***detect when a responder has arrived***, and log this automatically. Moreover, the ability to ***send coordinates from the incident site*** was suggested by both voluntary groups. This would be useful in cases where the exact location of the incident site is uncertain or approximate. Being the first on site, the voluntary responders could then easily send the correct coordinates to the professional responders so that they reduce their response time. To be able to ***send pictures and video from the incident site*** was discussed by both voluntary groups (in Test 2 and Test 3). The professional emergency personnel who supported the tests said that information from the incident site might be very useful, especially the number of victims.

From the tests with citizen volunteers, it became evident that the development of the application must take into account the ***technical maturity*** of the intended users. Many potential participants did not have an Android smartphone or could not download and install the application, which was a prerequisite to participate in Test 3. Of the ones who did participate, some had received help from friends or family to get ready.

The Same Solution for Different Volunteer Groups

The results indicate that the functionality offered by the tested smartphone application was sufficient for both volunteer groups, so the same solution can be used for different types of volunteers. While the majority of the identified functions were relevant to both groups, some differences emerged. The perceived relative importance of some functions differed, just like opinions about the design – not intuitive enough. It should be noted, though, that this partly might be due to the context; for example, citizen volunteers in Case 2 already had an existing, working solution (SMS) to compare the application with, or due to differences in test design, as Tests 1 and 2 were not performed in the same way as Tests 3 and 4. Thus, the study indicates that the basic ICT needs of different groups of voluntary first responders are similar and can mostly be implemented using the same functions. While some specific functions might differ, the same solution can easily be adapted to satisfy these, by adding, removing or revising some functions.

DISCUSSION: ICT AS AN ENABLER IN NEW FORMS OF GOVERNING AND CO-PRODUCTION

ICT opens up new forms of governing and improved resilience in public-service delivery, not least in emergency response. Volunteers can be engaged and collaborate with public bodies to improve services for others and themselves through co-production (Linders, 2012; Pestoff et al., 2012). However, in order to realise this co-production, suitable technological solutions are necessary. Although the ICT artefact and its surrounding collaborative infrastructure are closely interconnected, it can be fruitful to separate them and study the ICT artefact solely in order to enhance our understanding – especially if the context of the ICT artefact have already been explored (Alter, 2002).

Here, the involvement of end users is essential (Bjögvinsson et al., 2012). Still, there are few, if any, studies on co-production focusing on the ICT artefact with end-user involvement. In the information systems (IS) research field, on the other hand, there are some studies relating to user participation in emerging public-sector community initiatives (Bjögvinsson et al., 2012; Robertson and Simonsen, 2012). In the specific area of volunteers, emergency response and resilience, there exist studies on ICT solutions, but it is still difficult to find any in which suggested ICT functions and solutions are solidly anchored in user needs (e.g. Ringh et al., 2011; Schönböck et al., 2016). This study contributes explicitly in this respect, since it focuses on suitable functions of applications who are directly based on user involvement, user needs and user experience. As for emergency response, an ICT artefact that is well suited to volunteer first responders' opens up new possibilities for voluntary co-production whereby the resources of professional emergency services can be saved and used more effectively, and at the same time a quicker response is enabled. From a wider public-sector perspective, the study opens up space for an interesting merger of co-production and ICT perspectives, in line with studies claiming the benefits of a cross-fertilisation of policy science and information systems research fields in general (Janowski et al, 2012).

Identifying ICT Functions with End-User Involvement

Capturing the specific ICT functions can be difficult and time consuming. The number of identified functions became extensive. Initially, 13 functions were identified and after testing approximately half of them, an additional four functions were identified. Through the involvement of the volunteers – the end users – these functions could be divided into two groups: functions that are absolutely necessary and functions that might be nice but are possible to manage without. For example, in Case 2, the volunteer initiative had been running successfully for over two years when the tests were performed. This indicates that the basic SMS-based solution was actually sufficient for the intended purpose, implying the necessary functions to be only the ability to receive an alert and getting brief information about the incident, including the location. However, additional functionality might lead to a quicker and more effective response. For example, the volunteers may notice the alert more easily and quickly with a louder and unique signal. Another example is the ability to see who else is responding, which could make the volunteers more comfortable about responding themselves. This may make them more willing to continue to devote their time and also enhance the collaboration with professional emergency services. This again points to the benefits of connecting co-production and ICT artefacts based on end-user involvement. It may be cost-intensive and time-consuming at the beginning but will be worth it enabling a long-lasting way of governing the response.

Applicability of the Results: International Perspectives and Disaster Response

Given that many basic first-response tasks are similar globally (e.g. first aid, fire extinguishing), many of this study's results should be transferable to settings in other countries, for instance, importance of an intuitive interface is probably general. It is likely that volunteers will not use the application very often since they are only complementing the professional emergency services. Thus, the number of alerts that a voluntary responder can expect to receive are few; in the studied cases, often less than one per month. Therefore, the responders will not have the opportunity to learn to handle the application through frequent usage. Instead, it has to be sufficiently intuitive, or test alerts have to be sent regularly, for the volunteers to have the chance to learn to use the functions. Intuitive interfaces are also argued for in previous related studies (Lanerolle et al, 2010; Havlik et al., 2016). Similar functions are also highlighted, for instance use of acknowledgements, bringing equipment, possibility to share information (between volunteers and between volunteers and professionals) and possibility to get feedback (Auferbauer and Ganhör, 2015; Schmidt et al, 2018; Schönböck et al, 2016).

In a disaster response context, at least three possible user groups can be discerned: the ones who are already volunteers for everyday emergencies, and volunteers specific to a current disaster, either through some established non-profit organisation, or spontaneous volunteers (Havlik et al., 2016; Ringh et al., 2011; Whittaker et al., 2015). While disaster response volunteers connected to such organisations as the Red Cross might have the time and ability to become acquainted with an ICT solution like a smartphone application beforehand,

spontaneous volunteers will typically have no such experience. Thus, for this user group, the user friendliness of the application is even more crucial than when it is used for frequent, smaller emergencies (Falasca and Zobel, 2012).

CONCLUSIONS AND FUTURE WORK

This study set out to identify suitable functions in a smartphone application for volunteers in emergency response. The study's contributions thus relate mainly to the functions of the application, connected to the two voluntary groups in the meta-analysis. The study concludes that:

- Several functions were identified by both voluntary groups. Elementary functions comprised the ability to receive an alert on a mobile phone and receive sufficient information to be able to find the incident site. More specifically, this included functions as easy noticeable and unique alert signal, and an intuitive navigational aid to access and follow.
- However, there were also multiple functions identified that might contribute to the more effective utilisation of volunteers, reduce the first response times, and make the volunteers more comfortable in their role as first responders, making them willing to continue to devote their time, and enhancing the collaboration with professional emergency response organisations. Examples of functions for a more effective response and collaboration were a function indicating which equipment to bring, ability to send coordinates and pictures/videos from the incident site to professional resources, and – particularly for citizen volunteers – to receive information about when other responding resources will arrive.
- Different volunteer groups can use the same basic functions, but opinions about the design and realisation of the functions might differ depending on user background and context.
- Generally, it is a necessity for the application to be intuitive and easy to use, since most of the volunteers will be infrequent users and have varied technological literacy – if the users have a low technological maturity they may need education and support when installing and using the application.

Several functions were identified for the volunteers' ICT solution (the smartphone application) and, during the evaluation, new needs were also identified – which need to be further analysed and tested through exercises in order to arrive at implementable functions. Future work should address this, together with the professional response organisations and the Swedish PSAP.

At a more general level, the results of this study may be a useful input to research on the development of support for volunteers in emergency and disaster management. In this study, we also tried to open up space for the merging of ICT and various network perspectives, specifically co-production. While we only provide a starting point in this respect, the trait can be pursued in future research investigating the linkage of the respective perspectives further, from the macro-societal level, to theory development, to practical information systems development and inter-disciplinary design teams, not least concerning new emergency response volunteer initiatives.

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ACKNOWLEDGMENTS

This study was made possible through funding from the Swedish Civil Contingencies Agency (MSB) and Norrköpingsfonden.