Interdependent Digitalized Co-production of Emergency Response: Requirements and Challenges

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ABSTRACT

There is an increased need for organized forms of volunteerism in emergency response but there is little research on how to implement them. We describe the form as interdependent digitalized co-production and contribute with a requirements specification of how local initiatives of collaboration between rescue services and volunteer first responders can expand through national coordination – for use in small emergencies and large-scale crises. Requirements are identified in relation to the individual, organization, society and information technology (ICT) support. Identified organizational and ICT-(inter)related challenges concern unclear mandatorship and brand, double private-state roles of the alarm operator, inability to make use of local knowledge and end-user perspectives in the ICT-development. Connecting this to theoretical contributions, we argue that there is a need to renew existing typologies of digitalized co-production, e.g., integrating perspectives from institutional isomorphisms.

Keywords

Emergency response, volunteerism, digitalization, co-production.

INTRODUCTION

Volunteerism in emergency response increases continuously. Studies mostly relate it to large-scale crises and spontaneous volunteers that use social media channels to self-deploy and organize themselves for on-ground response work (Abdulhamid et. al, 2021; Batard et. al, 2019). However, some studies also recognize volunteers as co-opted and pre-trained resources in collaboration with the rescue services or ambulance services in smaller emergencies, as local bottom-up initiatives supposed to sustain overtime (e.g. Blackwood et. al, 2023; Morand et. al, 2023; Jonsson et. al, 2023). Another example from Sweden is volunteers dispatched as first responders to predefined types of emergencies while waiting for the professional response resources. The initiatives are local, and the ICT artefacts used basic but fundamental to the dispatch and coordination of volunteers and, thereby, the outcome of the initiatives. Previous research has studied the initiatives, with a focus on digitalization/ICT as enabler and hindrance, and on developing models for local and national support (e.g., Pilemalm, 2022).

In a general context, the potential of digitalization to enable citizen engagement in public service delivery is sometimes referred to as *ICT-enabled or digitalized co-production* (e.g., Clifton et. al, 2017). Related studies often take a public administration, macro-level, top-down governmental perspective, highlighting the potential of ICT/digitalization to transform co-production and the relationship between citizens and government, (e.g., Mergel, 2015; Taewoo, 2012) They are often technology optimistic and common themes are large-scale citizen engagement enabled by social media, crowdsourcing, or innovation and living labs using advanced technologies (e.g., Noveck, 2015). Meanwhile, national authorities and organizations in Sweden aim to take the local volunteer initiatives, to a national level, providing support to all rescue services to start up and maintain own initiatives. This can be seen as an effort to achieve digitalized co-production, the other way round, moving from local initiatives to large-scale, macro-level efforts, and have been described as an emerging type of *interdependent* *digitalized co-production* (Pilemalm & Alkusaibati, 2024). In this study, we contribute to the knowledge on the implementation process of such local initiatives nationwide initiatives using Sweden as an example by providing an overall requirements specification. We also make theoretical contributions by integrating perspectives of digitalized co-production with perspectives from institutional isomorphisms.

Aim and objectives

The aim of this study is to provide an example of how digitalized co-production of emergency response may be achieved moving from local, bottom-up initiatives to the macro-governmental level. The specific objectives are:

- to present a requirements specification for national coordination of volunteers as first responders, including aspects of the individual, organization, and ICT-support,
- to identify related implementation challenges.

The study is a case study inspired by action research including stakeholder representatives from national to local level. We also delineate the concept's development from local initiative to national movement and contribute to typology development.

BACKGROUND

In this section we describe related work and the study context.

Related work: Volunteers as First Responders

There is still scarce research on organized forms of volunteerism with a focus on smaller emergencies. Alkusaibati & Pilemalm (2023) carried out a literature review which demonstrates the large-scale focus and, that most studies speak about digital volunteers, rather than digitalized co-production. However, recently, some studies have emerged. For instance, Blackwood et. al (2023) explored the Verified Responder project where off-duty professional responders volunteer in the US respond to out-of-hospital cardiac arrests (OHCA) via a smart phone app. Morand et. al (2023) focused on the Save a Life app in Switzerland, which provides cardiopulmonary resuscitation (CPR) guidance and location to the nearest defibrillator. Jonsson et. al (2023) studied the SMS-lifesavers where volunteers in Scandinavia are dispatched to OHCA, indicating a 30 days higher-survival rate when the system is in use. The initiative was initially a local collaboration but has expanded and in Denmark, the system has national coverage. Svensson et al. (2024) analyzed the arrival times of volunteers registered in the app, demonstrating faster response times. Matinrad & Andersson Granberg, 2023 argue that this type of volunteerism is deemed cost-effective since a volunteer cost little compared to a professional resource. Therefore, a profit is gained every time they perform useful action, even if they do not go every time or do something useful every time. As to ICT, Prytz. et al. (2022) argue that lack of geofencing/positioning means that some volunteers receive too many alerts, leading to alarm fatigue. They also conclude that skill retention is a motivating factor to keep volunteers' engagement over time. In conclusion, most related work focuses on dispatch to OHCA, sometimes in combination with training in CPR. Meanwhile, the volunteerism type in our study is more organized and volunteer first responders dispatched to a broader range of emergencies

Study context

The idea of using volunteers as first responders in collaboration with the municipal rescue services emerged over a decade ago as a local initiative of a rescue service in sparsely populated areas in the north. The municipality rescue services are responsible for responding to frequent emergencies in their municipality, i.e., they are local, operative response organizations, not state authorities. They recruit volunteers and provide them with basic equipment and training. The volunteers are then dispatched to predefined types of emergencies, e.g., traffic accidents, OHCA, drownings, and certain fires, using their own ICT in terms of mobile phones, and apps. The most used app is developed by the Swedish Public Answering Point (PSAP) which is the state alarm operator, half owned by the state and half private. The aim is to shorten response times by dispatching volunteers close to the emergency site so that they can start first response before the professional resources (the rescue services, the ambulance services) arrive.

The concept was picked up by other rescue services in rural areas. Also, a large fire association transferred it to urban settings and socially vulnerable areas. Previous studies show how this type of collaboration/co-production is appreciated and effective, where lives have been saved and buildings prevented from burning to the ground (e.g., Pilemalm & Alkusaibati, 2024). It is increasingly recognized by local rescue services and national authorities for crisis management that emergency response cannot cope without volunteerism. Still, the growth is slow, with only about 25 of about 300 rescue services applying the concept, engaging about 500 volunteers. Identified explanations include organizational challenges, e.g., no allocated time and budget, perceived low support from the own management and as regards national coordination, lack of policy-making and unclear legislation on work environment responsibility. As to ICT, the PSAP app lacks geofencing, several ICT solutions exist, and the PSAP has an unclear double role as a state authority and private actor, blocking commercial suppliers from their back-office systems and from central functionality (Pilemalm, 2022).

Several rescue services point to an urgent need to provide national support for local rescue services that want to implement volunteer initiatives. Recently the Swedish Fire Protection Association (FPA) took a leading role in this work. They are a national non-governmental organization and financed through private donors and memberships. FPA are represented by 20 local associations who cover all rescue services nationwide. FPAs intended support includes, e.g., coordination, developing a system for registering and handling volunteers, in-service training, improved dispatch solutions, insurance, etc. Also, the Swedish Civil Contingencies Agency (MSB), has declared an interest to make the local volunteers initiatives spread, working close with a large rescue service. MSB is the state national authority coordinating crisis management, residing under the government. In other words, governmental, macro-level efforts are – independently of each other - taking place to make use of locally generated knowledge.

ANALYTICAL FRAMEWORK

In this section, we present the study analytical framework, combining perspectives from ICT-enabled/digitalized co-production, institutional isomorphism and requirements elicitation.

ICT-enabled/digitalized Co-production

In co-production, citizens are an active part of public services' design, steering, and management (Ostrom, 1996). It is increasingly seen as a necessity when public sector resources are cut. Several studies has underlined the increasing role of digital technologies, using terms like "ICT as an enabler" and "ICT facilitated co-production," (e.g., Paletti, 2016). While co-production overall has many application areas, ICT-enabled or digitalized co-production often refers to governmental strategies involving policymakers, where digital technologies can redesign government services to fulfill user needs of large citizen groups (e.g., Mergel 2015). While related studies tend to be technology optimistic, some recent studies question this optimism. Lember et. al (2019) claim that the debate has been characterized by conceptual fuzziness where challenges such as investment of resources and motivation of citizens are not sufficiently addressed. They argue that digitalized co-production must be supported by organizational resources, if digitalization should act as a facilitator. Nieuwenhuizen & Meijer (2021), claim that ICT/digitalization, if used in transformative or substitute manners, may challenge values of proper governance, lawfulness and integrity. A few literature reviews include structural, cultural and ICT-related barriers in ICT-enabled/digitalized co-production, e.g., lack of resources, lack of competence or will of the personnel, and costs for ICT platform maintenance (Yan, 2019; Clifton et. al, 2020).

Recently, some studies focusing on the local level of ICT-enabled co-production have emerged. For instance, Nemeck et. al (2019) explore local self-government supported by digitalization in municipalities in Slovakia. In the emergency response context, the volunteer initiatives have been identified as an emerging *interdependent* type of digitalized co-production (Pilemalm & Alkusaibati, 2024). Here, volunteers engage in long-term collaboration with the rescue services but are organizationally unaffiliated, i.e., the rescue services have no formal responsibility for them. The type is bottom-up where local fire chiefs have initiated them, not the rescue services management level. Neither have they been preceded by any clear governmental strategy. In this study, we focus on the national level with a point of departure in local initiatives, i.e., moving from micro- to macro-level.

Institutional Isomorphism

From an organizational perspective, the interdependent type of co-production introduces new actors to an organizational field, in this case emergency response. It also introduces new ways to structure the field of professionals and volunteers in rescue activities. By growing from local initiatives to national coverage, the initiatives will challenge many institutionalized routines and ways of thinking in the field of emergency response and likely meet resistance to overcome. The resistance or pressure to conform can be described as *institutional isomorphism* (DiMaggio & Powell, 1983) using coercion, norms or imitation. Nicholls (2010) added *reflexive isomorphism* where the established actors will respond to new initiatives by pressure to conform to a given institutional actor's logic, or views. We add this perspective when analyzing the identified challenges, to contribute to the literature body on ICT-related/digitalized co-production, and to new ways of using institutional isomorphism.

Requirements Elicitation

In information systems (IS) development and requirements elicitation, co-production can be related to concepts of co-creation, co-design and participatory design (PD) (Jones, 2018). In this study, we take a socio-technical ensemble view (Orlikowski & Iacono, 2001) where the co-production includes a central ICT artefact for dispatch, and an IS for coordination, and interrelated organizational challenges. We also follow in the traits of co-creation/co-design/PD, in that we seek to involve end-users (volunteers, local rescue services) and other stakeholders in the development of the digitalized co-production under study.

METHODS

In this section we describe the overall research approach, data collection and analysis.

Case Study and Action Research

This is a case study (Myers, 2009) addressing the phenomenon of volunteer first responders in emergency response, in a wider sense, interdependent digitalized co-production. Complementary qualitative methods have been combined to gather the requirements, for iterative building of knowledge. The study is also inspired by action research. Case studies can be combined with action research to allow for both the understanding of a setting and performing intervention within it (Vidgen & Bra, 1997). In our case being "inspired by action research" implies that we are involved in the development of the volunteer initiatives, specifically, in improving the ICT dispatch and IS coordination. We thus take a double role as developers and participant observers, as well as providing recommendations and requirements to the rescue services and the national authorities. However, we do not take part in implementing the recommendations.

Workshop, Focus Groups and Participant Observation

A one-day workshop was held with 12 stakeholder representatives, from the two national organizations, the rescue services, the PSAP, a commercial supplier, and the volunteers/end-users. The aim was to gather representatives from all stakeholders that are somehow involved in or affected by the national coordination of volunteers. The commercial supplier provides the app for the previously mentioned SMS-lifesavers and has relevant competence for the ICT dispatch. The stakeholders are listed in Table 1 together with their role in the workshop and what level in the emergency response system they come from. In the workshop, they were divided into three focus groups (Myers, 2009) working through the themes: *the individual, the training and the equipment*, *organization and society* and *dispatch and ISs for coordination*, with related questions. The themes are central to the volunteer initiatives, considering previous research, and the purpose of national coordination. After the focus group work, the results of each group were discussed in a large group session. The researchers acted as participant observers in respective groups taking memory notes but also asking questions or asking for clarification, thus reflecting the double role(s) of researchers and developers.

Table 1. Stakeholder representatives and their respective role/level.

Organization and volunteers	Role/level	Number of representatives
Swedish Civil Contingencies Agency	National coordination	2
The Swedish Fire Protection Association	National coordination	2
The municipal rescue services	Local/municipal/end-user	4
The Swedish Public Answering Point	National, half state owned/half private	2
Volunteers	End-user	1
SMS-lifesavers	Supplier/seller	1
Total		**12**

Stakeholder/end-user Interviews

Seven semi-structured interviews with volunteer first responders and responders from the rescue services were held (Table 2). They intended to explicitly include the perspective of the end-users, specifically the volunteers. This, since it was difficult for them to devote time to an entire day/workshop. The interviews follow a semi-structured approach, i.e., an interview guide with open-ended questions (Myers, 2009). Themes concerned national support, including how digitalization/ICT could be used for support. All interviews were audio recorded and transcribed.

Table 2. Interview respondents

Rescue services	3
Volunteers	4
Total	**7**

Analysis

First, a thematic analysis (Myers, 2009) was used. The overall themes from the workshop/focus groups guided the first analysis round of memory notes. Data was clustered, and sub-themes emerged in relation to the overall themes. For the interviews, data related to the identified themes were similarly clustered. Two of the paper authors participated in the workshop and in the subsequent data analysis. The third author carried out the interviews and analyzed the data. From the themes, requirements were identified and prioritized by the first author of the study. Prioritization (Priority 1-3) is based on what the volunteer end-users and other stakeholders have pointed out as most urgent, but also on what we know is feasible in the near-time development of the initiatives.

RESULTS

The themes with are presented with related sub-themes and corresponding requirements are summarized in Tables 3-7. Analysis of related organizational and ICT challenges are presented along the identified requirements.

The Individual the Training and the Equipment

A central subtheme was the need to *define* what a volunteer first responder is in relation to other types of volunteers (e.g., spontaneous volunteers) and what *capabilities* they should have. There was agreement in the workshop/focus groups that volunteer first responders are citizens that are trained, equipped and dispatched, and act on a voluntary basis, i.e., on the overall definition. However, at a detailed level, there was no consensus of what the definitions and capabilities should include. According to the MSB view, the volunteers should reside within the rescue services and each municipality decide whether they want to start volunteer initiatives. Tasks should be limited to those currently existing, i.e., providing first response/aid in traffic accidents and drownings, extinguishing small fires and CPR. Response is "waiting for", e.g., the volunteers handle over tasks when the professional resources arrive. The FPA, on the other hand, has a vision of 1% of the Swedish population being volunteer first responders in 2030. They view this development as a change of mindset and a popular movement to increase resilience, including double use of volunteers in crises. They stated that "we cannot afford to say no to anyone who wants to sign up as volunteer" and see a much broader range of tasks for volunteer first responders. The rescue services' perspective was somewhere in between, wanting to build the expansion stepwise and starting small-scale. The volunteers, both in the workshop and interviews, are generally eager to expand their role and type of incidents to act upon (including emergencies, crises and as part of civil preparedness). Finally, it was agreed that one way does not exclude the other, if the process takes place stepwise, leading to the following requirements (Table 3):

Table 3. Definitions of volunteers as first responders

Requirement	Requirement description	Priority
Definition	A clear definition of what a volunteer first responder is, e.g., that they are trained, equipped and dispatched.	1
Delimitation	A clear definition of what a volunteer first responder is not, (e.g. a professional, a semi-professional, a bystander, a spontaneous volunteer, or someone belonging to a non-profit organization).	1
Competence ladder	A competence ladder where one can advance stepwise from spontaneous volunteer to volunteer first responder to specialist/building of competence in certain areas.	2

Various stakeholders pointed out that the municipalities must know what to expect from a volunteer first responder (Table 4). Then they can choose whether to join the initiatives or not. There are other initiatives going on in some municipalities/rescue services involving a volunteerism type similar to the SMS-lifesavers, i.e., you receive no training or equipment but can use an app developed by the workshop commercial supplier, and are dispatched to nearby fires, doing what you can. Therefore, it is important that someone provides a uniform definition. In a competence ladder, it might be possible for certain specialists to sign up, e.g., as "duty as fire fighter" and be summoned by the rescue services if a crisis occurs. In the interviews, the rescue services respondents pointed at the need for agreements that regulate tasks of volunteer first responders.

Table 4. Required capabilities of volunteers and what tasks they can perform

Requirement	Requirement description	Priority
Basic capability to act in first response to small-scale emergencies	Basic capability to act on traffic accidents, smaller fires, drownings and out-of-hospital cardiac arrests. Tasks include extinguishing fires, CPR, first aid, calming chocked people, directing the traffic et c.	1
Contract/agreements	Contracts/agreements that volunteers sign, regulating what tasks they perform, based on their basic capability.	1
Further capability to handle incidents over time	Further capability to act in emergencies after the initial response. Tasks may include monitoring a forest fire, pump water in floodings, decontamination etc.	2
Further capability to act in large-scale incidents.	Further capability to act in extraordinary events and large-scale crises. Tasks may include transportation, distributing food, blankets and medications etc.	2
Further capability to act in other types of incidents.	Further capability to act in other types of incidents, e.g., in suicidal alerts, in trauma care, and in search and rescue. Tasks may include CPR on children etc.	3
Further capability to act as part of civil preparedness	Further capability to act as part of civil preparedness/a civil defense.	3

The discrepancy between developing the initiatives small-scale and stepwise versus seeing them as vital parts of increased societal and community resilience, was again observed. The MSB and the rescue services argued that it is easy to lose control over the volunteer initiatives and make them too complex. Also, including more types of incidents requires a functioning withdrawal function in the app. Arguments against limited use of volunteers were that it may refrain municipalities from implementing the initiatives, and that some volunteers already are placed within the total defense and possess related capabilities. The FPA argued for turning the perspective, i.e., what must the volunteers *not* be alerted to. It was agreed that a "low-hanging-fruit" is that the volunteers become part of the municipal "safety points" that are set up in crises, providing e.g. food, blankets and trauma support. From the interviews, some volunteers expressed that they could do whatever was requested in case of crisis or war (except bearing weapons). Others declared that they would do first response tasks but that there are other non-profit organizations/spontaneous volunteers that carry out e.g. transportation and distribution of food.

As regards *training and equipment*, there was more consensus in the workshop. Training concepts should follow the competence ladder and capability descriptions and be divided into basic and further/advanced training. Similarly, equipment should be divided into basic equipment provided by the FPA or the rescue services and advanced equipment that the volunteers may choose to purchase themselves (Table 5).

Table 5. requirements on training and equipment

Requirement	Requirement description	Priority
Basic training for first response	Basic training includes first aid, CPR, handling handheld fire extinguishers, risk awareness, behavior at incident site, basic juridical matters. It should be carried out either by the FPA local-organizations or the rescue services.	1
Standardization of basic training	Basic training should follow a national standard, i.e., be similar across rescue services	1
Repetition	Repetition of training.	1
Basic training for rescue services personnel	Training of the rescue services personnel to recognize the volunteers and collaborate with them.	1
Basic equipment for first response	Basic equipment includes, e.g., reflective vests, gloves, first aid kits, and powder extinguisher. It should be provided either by the FPA local-organizations or the rescue services.	1
Further training for specialization	Further training in special skills, e.g., handling flooding, more advanced fire extinguishing. It can be suited to various geospatial settings.	2
Additional equipment for first response.	Additional equipment may include defibrillators, tourniquets, heart rate monitors, etc.	2

Reflected both in the end-user interviews and the workshop, many volunteers do not think the basic equipment is sufficient. There are examples where they have organized themselves locally and bought their own equipment, e.g., helmets, head lamps etc. The rescue services are of the opinion that "provided equipment is sufficient equipment" and basic equipment what they can afford, given maintenance costs. Too much equipment also creates expectations in the role. They do not mind that the volunteers buy their own equipment. But there are limitations. One respondent mentioned a case where the volunteers have succeeded in getting sponsors to invest in cutting equipment, even if they should not be involved in such tasks.

The discussion emphasized collaboration on training and MSBs' part in supporting the rescue services and the FPA. They could provide a web-based course that is open to the public (to increase skills in CPR etc.) and information on the volunteer initiatives and how to become a volunteer first responder. It was also argued that "train-the-trainer" concepts, i.e., experienced volunteers train new volunteers is good for repetition but not for basic training. Also, the question of whether it would be possible to validate training (i.e. to demonstrate that one has acquired the skills taught and practiced) with a point of departure in the competence ladder, was raised. In the interviews, the rescue services and the volunteers pointed out the importance that all volunteers access the same training/education. Currently, it is a substantial difference between rescue services.

Organization and Society

The identified requirements related to *roles, responsibilities*, and *follow-ups* of the volunteer work is sumaarized in Table 6.

Table 6. Requirements on organization and society

Requirement	Requirement description	Priority
Roles and responsibility	Definitions of roles and responsibilities in the national coordination of volunteer initiatives	1
Mandatorship	FPA mandatorship for rescue services who start-up volunteer initiatives. Existing initiatives choose if they want to join or continue in-house mandatorship.	1
National/governmental support	National/governmental support of the initiatives. MSB should acknowledge officially that they support the initiatives, e.g., through official websites	1
Technology dispatch support	Further development of the dispatch technology to enable adequate, effective dispatch. PSAP has the leading role/responsibility.	1
Financial support	Governmental and sponsor support to enable expansion of the volunteer initiatives and ICT development.	1
Involvement of additional stakeholders	Involvement of more stakeholders to increase societal knowledge and understanding for the volunteer initiatives. For instance, the Police and the municipality management.	2
Rescue services follow-up mechanisms	Development of the rescue services incident report system, to include participation and tasks of volunteers. The rescue services personnel could be trained to fill in this information and the regional level follow-up the documentation.	2
MSB/FSP follow-up mechanisms	National compilation of regional documentation to estimate effects. The reports could serve as guidance for municipalities.	2
PSAP follow-up mechanisms	Accurate statistics of response times, i.e., time stamps showing the volunteers' arrival and departure from the incident site. Possibility to see what kind of alerts volunteers are dispatched to.	2

There was consensus on the overall roles of various stakeholders, however, there was some tension regarding the mandatorship in relation. While MSB do not want to have this *responsibility* they still view themselves as a central platform for the volunteer initiatives, especially through their agreement with the large local rescue services who will support spreading the concept. Among the rescue services the opinion varies. One respondent argues that there may be fear among municipalities to take responsibility because of a rising workload. Then, it might be better to be organized by a non-governmental (FPA) association. Others want to retain their autonomy but are willing to use those parts of the FPA support they deem usable. As to the financial requirements, the FPA wants to sign agreements with all rescue services. They will however need sponsors from private companies and governmental bodies. They have attracted positive attention from both types, but no concrete promises of financing.

Involvement of other stakeholders and societal recognition of the volunteer initiatives is currently low. It is of particular importance to involve the Police so that they know who the volunteer first responders are, when encountering them at an incident site. In the interviews, several volunteers turned the perspective and said that it would be interesting to learn from things that happen around the world. An example mentioned was from an explosion in Lebanon. Information could be shared with the volunteers so that they know what type of injuries they can expect from a person x meters from an explosion.

Both the workshop stakeholders and the interviewed volunteers claim that not only effects and response times should be documented and communicated (*follow-up mechanisms*), but also "soft values" like safety, resilience, and an increased feeling of community. Here national authorities have a responsibility for communication. All volunteers in the interviews declared that it is important that they continuously receive relevant information about volunteer initiatives, e.g., on what happens in other areas than their local, if an initiative has started in a new area etc. This would increase their interest and motivation to continue as volunteers. The rescue services interviewees agreed that it is important to have a channel for providing the volunteers with news and continuous information. Both volunteers and rescue services also express an interest in receiving some statistics monthly, e.g., how many alerts they have received and what type of alerts they have intervened in. The rescue services argue that this is important to coordinate things with the volunteers in the follow-up mechanisms.

Dispatch and IS for Coordination

The requirements can be divided into requirements on the app for dispatch and for an overall system portal/IS as listed in Table 7-8.

Table 7. Requirements for dispatch of volunteers

Requirement	Requirement description	Priority
Geofencing/positioning	Geofencing/positioning with a flexible radius so that only volunteers near the incident site are dispatched. It should be possible to receive the alerts whether you are in your own municipality or not.	1
Alarm groups	Larger alarm groups and test alerts in certain areas with few alerts, to keep volunteers motivated.	1
Restrictions	In-built restrictions for e.g. highways, or high-risk areas to create a safe environment for the volunteers	1
Withdrawal of resources	The current functionality for withdrawal must be usable, including the possibility to up-date an alert, and communicated through a loud signal.	1
Time stamping	Functionality to time stamp, to see when a volunteer arrives at/leaves the incident site.	1
Brief incident report	Functionality where the volunteers answer a few questions after each incident.	2
Pictures	Functionality to send pictures from the incident site to the rescue services	2
Dynamic resource allocation	Functionality to enable pre-selection of profiles and what type of alerts a volunteer wants to receive	2
Dynamic resource allocation	Functionality to dispatch based on capability, competence, equipment etc.	2

The dispatch requirements are, in certain ways, contradictory. The highest priority requirement is the geofencing/positioning – to enable effective response and avoid alarm fatigue. This is underlined in the workshop and by the volunteers in the interviews. The PSAP, however, argues that the app development concerns their role as state alarm operator. They must also provide robustness of this function. If they are to develop the app further, they need state/governmental support and MSB should speak on their behalf. The rescue services, on the other hand, argue that the PSAP is half state, half private owned and receives good payment for their app from the rescue services. MSB argues that as national coordinators they have no money available for this and that it is questionable if it is their responsibility to take the finance issue further. Rather, the municipalities themselves must be better specifiers of the volunteer initiatives and the ICT support. It is also notable that there are commercial apps on the market. The SMS-lifesavers app has been able to provide geofencing for long and was, recently developed for use in rescue services to dispatch voluntary citizens on small fires (however; without training and equipment).

Further, the withdrawal function – which is central when a situation escalates/becomes dangerous to the volunteers - exists in the PSAP app. But it is not used. The volunteers believe that they might not hear it since it does not have a distinct signal. Another explanation is that the PSAP alarm operators do not use it (even though they can see who went on the alert and how the situation unfolds). The rescue services, in turn, cannot access the withdrawal function and they too sometimes miss alerting the volunteers. The problems may be addressed by standardization and a joint Application Programming Interface (API). But the PSAP seems unwilling to release their API. The reasons mentioned include who owns the alerts/data, an upcoming ISO certification, but also that some instances in the organization might want to have to pay for sharing data. In other words, they act in their role as private suppliers. Meanwhile, the volunteers are increasingly frustrated, claiming that "it feels like the rescue services and authorities just say that this functionality comes later, and then another year passes".

The system portal for the coordination of the volunteers is, on the other hand, already under development. The first version has been released. It is a member management system where one can register interest, and either be directed to the rescue services if there is a volunteer initiative in the own municipality or be registered by the FPA for the future, if there is not. Contracts on GDPR are signed. Thus, the portal exists but most functionality in it is missing. In the interviews, volunteers and rescue services respondents provided rich information on what a system portal should include, in terms of instructions, checklists, tips and tricks, guidelines, a Frequently Asked Questions section and reports that volunteer can fill in after an incident. They also want access to the aforementioned information and statistics (Table 8).

Table 8. Requirements on system portal for coordination of volunteers

Requirement	Requirement description	Priority
Contact information	Contact information that enables two-way communication with the rescue services, and among volunteers	1
Feedback functionality	Feedback functionality enabling two-way communication on future needs and requirements	1
System portal for dynamic resource allocation	System support for storing competences and profiles	2
System portal for training/exercises	System support for storing information on various levels of training/exercises connected to volunteers' competence profiles/competence ladders	2
System support for MSB/PSAP/FSP follow-ups	System support to enable the follow-up mechanisms including statistics	2

System support for checklists/information material	System support to store checklists, FAQ and information material, e.g., how to act in various types of incidents.	2
Exchange of experiences	Functionality enabling horizontal exchange of experience between volunteers, e.g., of incident reports	2

Also, while the current design of the portal is top-down, both the volunteer and rescue services respondents emphasized two-way and horizontal communication. This includes contact information where they can contact each other, and peer-to-peer communication among volunteers. Rescue services can use feedback mechanisms to offer voluntary learning experience, and volunteers can request e.g. further training. The volunteers also want to be able to share experiences among themselves, in their local group and with other volunteers nationally.

Further, a listing of competences and profiles needed for dynamic resource allocation and potential upscale to large crisis is requested. Several stakeholders in the workshop emphasize that many volunteers have occupational competences such as nurses or doctors. Several of the volunteers point out that they have "extra competences", e.g., are trained in CPR on children or are part time firefighters. Finally, there is much limited knowledge on the portal. The municipalities need to know that it exists and may be used for the recruitment of volunteers.

DISCUSSION

We first discuss interdependent digitalized co-production of emergency response including perspectives of institutional isomorphism, and the implications in a wider ICT-enabled/digitalized co-production context. We then reflect on the importance of user participation and on study transferability and limitations.

To Implement Interdependent Digitalized Co-production

To implement *interdependent digitalized co-production* of emergency response (Pilemalm & Alkusaibati, 2024) and take local initiatives to a national, macro-level, comes with challenges. In the study, several conflicting views were discerned. While the stakeholders agreed on overall roles, equipment and training, MSB and the FPA define the volunteer first responders differently, much as reflections of their own views on their fields of activity. MSB, who has taken on the task of spreading the concept (but not necessarily do the coordination of the work) views it as *an extended rescue resource*. From the agency's perspective the volunteers should tie to the rescue services and their needs, and their tasks limited to first response mainly in small-scale accidents. This means that respective municipalities and their willingness to train, equip and dispatch volunteers to incident sites will define the local concept of a volunteer first responder. The FPA rather sees volunteer first responders from a civil society perspective to create *long-term resilience and civil preparedness for the whole society* on a national scale. They adopt a "let all the flowers bloom" view where the volunteers have broad roles and competences and fulfil various societal safety-related tasks. For instance, they have released a portal where anyone can register, regardless of whether they have a municipality/rescue services belonging. We thus have contradictory standpoints where the FPA argues that you cannot turn down volunteerism if you want to keep volunteers' motivation and has started to organize them without dispatch affiliation, using forced establishments to overcome MSB's resistance. Meanwhile, MSB argues that the matter needs settling before operative work can proceed and does not want the FPA to use "volunteer first responder" as their brand. The rescue services, on their side, become left out in this process and express frustration as the operative work and the national support they have requested for a long time is halted. The major rescue service that has written an agreement with MSB on taking a lead in spreading the initiatives is left with a status-quo position.

The conflicting views are examples of how different logic in different societal sectors leads to clashes and frustration when they are not anticipated. Wijkström (2011) speaks of hybridization between different sectors' activities, both organizational actors who start activities in another sector, such as the Red Cross going into business, or in the case of collaboration between actors from different sectors, as in the study. Their way of handling the situation shows similarities to what Nicholls (2010) labels *reflexive isomorphism* were the thoughts about the new concept and its affiliation, reflect the main actors' own views and activities The public agency (MSB) wants to take small steps and minimize the risk of unanticipated questions and situations to secure their trustworthiness and legitimacy with the rescue services. The FPA is campaigning to "the people" to get legitimacy by getting things done. A third party, a commercial supplier, presents their app alternative without much responsibility for the rescue services who use their service, although it is a considerably more expensive alternative. Thus, the actors search for legitimacy in different ways, suited to their respective ways of thinking.

As to the ICT-enabled dispatch, there is a similar conflict between the state and the private. The public sector actors, from national to local level (the rescue services) claim that for geofencing the PSAP must act in their role as state alarm operator, prioritizing this function. The PSAP on their side, act in their role as a private company expecting revenues. We thus end up with closely interrelated organizational and ICT challenges, again reflecting reflexive isomorphism. Below, we describe implications for ICT-enabled/digitalized co-production.

Implications for ICT-enabled/Digitalized Co-production

Interdependent digitalized co-production of emergency response - based on ICT-dispatched on-ground first response - entails more complex attributes than those suggested in previous typologies on digitalized/ICT-enabled co-production (Yan, 2019; Linders, 2012). Over a decade ago, Linders (2012), and Taewoo (2012), called for upgraded typologies of ICT-enabled co-production forms. Linders (2012) also developed a new typology out of the many models that emerged after the introduction of social media, introducing, among other things, *do-it-yourself government*, which in the emergency response context would be closest to spontaneous volunteers . Later, Yan (2019) defined three types of ICT-enabled co-production: *Automatic Co-production* where governments rely on advanced technologies to aggregate data with almost no active participation from citizens, *Government as an Open Platform* where the government disseminates data to “tech-savvy citizens” to solve public service provision issues, and *Citizen-sourcing*, where government organizations make an open, direct call to a large community of citizens to exploit their skills for public services tasks, mainly using online platforms.

Interdependent forms of digitalized co-production are closest to citizen sourcing but also deviate from this type. Here, targeted efforts, information campaigns, local interest groups, outreach work and low-tech solutions that mostly offer one-way communication are used. Also, the volunteers play an *active* role in multiple ways; they receive training, act as first responders on the ground and sometimes provide feedback to the rescue services. Also, governmental outsourcing is not direct but has been mediated by various organizations, first at local level (the rescue services), and recently also from the national, macro-level (MSB, FPA).

From a theoretical perspective, the *interdependent digitalized co-production* of emergency response rather has overlaps with Ostrom’s original “*Polycentric Systems*” (Ostrom, 1996). Here, various units or governing authorities coexist, and formal actors provide other actors with the means to organize their own governing bodies. Each unit has distinct responsibilities within its assigned areas, contributing to the overall functionality of the entire system. The interdependent co-production type adds the central aspect of digitalization. The existing typologies on ICT-enabled/digitalized co-production and their similarities and differences to *interdependent digitalized co-production* are summarized in Table 9.

Table 9: Comparison of various types of ICT-enabled/digitalized co-production

Type	Study	ICT	Government role	Citizen role	Intermediary role
Citizen sourcing	Linders 2012; Yan 2019	Social media	Calls for citizens to provide information or contribute to services	Consultant, sometimes active contributor	No
Government as platform	Linders 2012; Yan 2019	Social media; data mining	Data provider, data collector	Informant, consultant	No
Automatic co-production	Yan 2019	Artificial intelligence, data aggregation	Data collector	Informant	No
Do-it yourself government	Linders, 2012	Social media	None	Service provider, e.g., spontaneous volunteers in emergency response	No
Interdependent digitalized co-production	Pilemalm & Alkusaibati; 2024	Apps, organizational back-office systems, system portal	Service outsourcer, service consumer, service provider	Service provider, Service consumer	Outsourcing mediated by local (municipal) level and national authorities

Interdependent digitalized co-production has several similarities to the other types. It reflects the Lember et. al (2019) view that ICT should not be a facilitator taken for granted to co-production. It shows the need to secure financial support for ICT maintenance costs, for policy making and administrative frameworks, and the challenges of institutional conflicts, similarly to the Yan (2019) and Clifton et. al (2020) literature reviews. But there are also other challenges, some general, some specific to the emergency response context. First, the ICT is not social media or sophisticated data mining technologies but apps and IS for coordination. Above all the apps seem basic but still they and related dispatch routines halt the expansion of the initiatives. We thus have a larger focus on *ICT development* and related costs than in the other types. This reflects the gap in the roles of ad-hoc mobile applications in emergency response described by Abdulhamid et. al (2021) and shows that it extends to interdependent digitalized co-production. Also, there are specific costs relating to the volunteer *training, equipment, insurance,* and *skill retention* over time. This, in contrast to other types where citizen groups are larger, open and easily replaceable. Strategies to handle development and costs must be addressed at an early stage should interdependent digitalized co-production scale up and result in long-term return on investment.

In relation, while organizational resources are a challenge also in the interdependent setting, it is more complex, including the intermediate level and pronounced inter-agency collaboration. A major conflict evolves around power and brands – which ultimately leads to the question of who controls the volunteers in interdependent digitalized co-production. When the responsibilities are not sufficiently distinct or defined, a breakdown in the system occurs. When the volunteer initiatives started over a decade ago, studies pointed to the need to focus on organizing the desired activity, i.e. the provision of safety, and not on the organizations or actors themselves (Pilemalm et. al 2013). This means a break with all organizing built on the Weberian iron cage of professionalization (DiMaggio & Powell, 1983). When the initiatives now have moved to the national, macro-level, the focus seems to have retreated to the organizations and raised questions of who has the authority, legitimacy and profession and who has not, and what authority and legitimacy means for the specific organization. There is thus a risk that the iron cage is re-introduced. In conclusion, there is a need to create a balance between steering, control and the support of the activity (in this case first response) itself, should the interdependent digitalized co-production type sustain and scale up over time.

User Participation in Co-production of Public services

User participation reflecting the socio-technically ensemble view (Orlikowski & Iacono, 2001) has many overlaps with the co-creation aspect of co-production (Jones, 2018), not the least as regards requirements elicitation. Somewhat ironically, neither the PSAP app nor the system portal under development, has been developed together with the volunteers/end-users. In other words, the initiatives, when moving to the macro-level, do not make use of locally generated knowledge. There are difficulties involving the volunteers in ICT development over time, due to their ordinary jobs. When the initiatives still were local, many project leaders/rescue services devoted their evenings and weekends to develop the initiatives with the volunteers. Another explanation might be related to institutional isomorphism, and an organizational fear of losing control of the volunteers. This can be exemplified by the system portal which is designed from a top-down perspective and where the national stakeholders solely list top-down requirements. Meanwhile, the local level and the volunteers emphasize functionality enabling two-way and peer-to-peer communication and collaboration. It seems crucial that interdependent digitalized co-production is not captured by macro-level national organizations but also seek to involve end-users in ICT-related and organizational development, reflecting the socio-technical ensemble view. In the initiative, many flaws could have been eliminated much earlier, had the volunteers been involved.

Study Transferability and Limitations

The identified requirements are most relevant to volunteerism in emergency response. This type of volunteerism is emerging also in other countries (e.g., McLennan, 2022) and the findings should thus be internationally relevant/transferable to, in specific, countries with similar decentralized emergency response systems. They are also relevant to management of large-scale crises, since volunteer first responders will likely be a resource here too, due to their training, equipment, and experience. To test the study results transferability to similar settings, a setup involving stakeholders from local and national level in the response system and including end-users (volunteers), is required.

In a wider ICT-enabled/digitalized co-production context, the results should be applicable to emerging forms of the interdependent type. Volunteerism is growing and recognized in a world facing financial constraints while having to deal with restoring public services after the pandemics, rebuilding defense structures, etc. A need to move beyond spontaneous volunteerism to more affiliated and organized forms will likely spread and may involve areas such as locating missing persons (Linders, 2012), home care and certain forms of health care, indicating a need to renew typologies, identify and handle associated challenges.

As to limitations, the study is based on a workshop involving 12 stakeholders of whom one is a volunteer/end-user, and 7 additional stakeholders, including volunteers (interviews). The limited study sample may in part reflect personal rather than organizational views. On the other hand, many of the requirements have been reflected in related studies and the tensions identified also when we have spoken to other units in the organizations involved in the initiatives. However, since the sample size is limited, additional data collection is needed to confirm or revise the study findings. Also, more stakeholder perspectives, e.g., the regional level should be included, if the findings are tested in a replicated, similar case study setting.

CONCLUSION AND FUTURE WORK

This study provided an example of how interdependent digitalized co-production in emergency response may be achieved moving from local, bottom-up initiatives to the macro-governmental level. In specific, we addressed a perceived research gap on how to implement emerging forms of organized volunteerism and presented a requirements specification for national coordination of volunteer first responders and related challenges. Requirements were identified in relation to the individual, organization, society and ICT support. Identified organizational and ICT-interrelated challenges concern unclear mandatorship and brand, double private-state roles of the alarm operator and inability to make use of local knowledge and end-user perspectives in the ICT-development.

A key finding is that interdependent digitalized co-production of emergency response is different to and more complex to previous types of digitalized co-production. It requires another type of ICT (development), involves a different role for both volunteers and government and introduces intermediary local and national roles. There are also additional costs involved relating to training, insurance equipment and skill retentions. However, if these costs are handled strategically at an early stage, volunteer first responders will constitute a useful complement to spontaneous volunteers in small and large emergencies, since they are trained, equipped – and experienced. Connecting digitalized co-production to institutional isomorphism, we recommend that vital issues of power and control that this co-production type generate are handled. This, to avoid we risk retorting to the Weberian iron cage and keep the major activity – societal safety – in the process.

The requirements are a first step towards expanding the volunteer initiatives but must be addressed and major bottlenecks solved in future development. In future work we will address various parts of the overall requirements specification and related challenges, together with end-users and other stakeholders. We will also contribute to existing typologies of ICT-enabled/digitalized co-production, by making more detailed comparisons, adding theoretical perspectives from organizational theory and exploring transferability beyond emergency response.

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