Digitalized Co-production and Volunteerism in Emergency Response: a Literature Review

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ABSTRACT

ICT-enabled or digitalized co-production of public services has become increasingly relevant to emergency response and crisis management. This study provides a literature review on this phenomenon, exploring both large-scale crises and frequent emergencies. We found that research in the domain is scarce and focuses mainly on the phenomenon in terms of digital volunteerism. In large-scale crises, they mostly refer to spontaneous forms of volunteering, and in smaller emergencies, to more organized volunteers that collaborate with a response organization over time. Similarities to digitalized co-production in the public sector generally include financial, administrative, ICT, and demographic factors. Differences include, e.g., aspects of coordination, support, and processing by formal actors. We argue that there are benefits of adding a theoretical co-production perspective to digital volunteerism in emergency response and that our literature review can guide future research on models and (the double) use of volunteers in both kinds of emergencies.

Keywords

Digital, co-production, volunteers, emergency response, crisis response

INTRODUCTION

Public authorities encounter increased complexities in terms of deficiencies in fiscal capacities and increased challenges and demands, not the least in crisis management and emergency response (Whittaker et al. 2015). Developments of information systems (IS) and Information and Communication Technologies (ICTs) have also played a significant role in facilitating the inclusion of citizens as active actors in public services provision (Díaz et al. 2014; Yuan 2019). The phenomenon of including civilian actors in public services production was introduced by Elinor Ostrom in the 1970s as *co-production of public services*. She considered that by involving civil society, public governance is more able to result in efficient products (Ostrom 1996). Co-production is thus a process through which citizens take an active role in producing goods and services that are of interest to them (Brandsen and Honingh 2018). Due to the developments in ICTs represented by reinforced many-to-many communications, bottom-up initiatives, and digitally empowered citizen volunteerism, co-production received a revival last decades (Auferbauer and Tellioglu 2019; Brandsen et al. 2018; Paletti 2016).

Emergency and crisis response, as one of the public services traditionally offered by professionals, is experiencing an approach-shifting development. This is by actively cooperating with civilian volunteers as first emergency responders and vital sources of information (Albris 2018; Paletti 2016; Whittaker et al. 2015). However, some studies argue that ICT-enabled co-production in emergency response has not received explicit attention from scholars compared to co-production as a well-discussed phenomenon in the public administration domain generally (Paletti 2016). Rather, studies mostly discuss volunteerism in terms of bottom-up citizen volunteers initiatives facilitated by social media in response to crises, not referring explicitly to co-production.

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Pilemalm (2022), for instance, argues that citizen co-production in emergency response is commonly addressed by reviewing social media's impact on crowdsourcing, considering it as a taken-for-granted facilitator. Similarly, Abdulhamid et al. (2021), in their literature review on social media use in emergencies, argue that there is, on the contrary, a substantial gap in encompassing the roles of ad-hoc mobile applications in emergency response and communication. Therefore, the extent to which ICTs can be employed to support citizen volunteerism in emergency response, with what challenges, and under what conditions are some aspects that research should further investigate (Fraune and Knodt 2021; Qu et al. 2009). Also, most studies focus on digital volunteers' role in large-scale crises rather than small daily incidents such as fires in buildings or medical first aid. Meanwhile, also the latter take many human lives and cost society enormous amounts of money and resources (Pilemalm, 2022).

In literature reviews on ICT-enabled co-production, Yuan (2019) and Clifton et al. (2020) describe and systemize citizen co-production from a public administration lens. Given the general lack of co-production studies concerning the IS discipline and emergency response domains, we have not found any corresponding literature reviews. However, Whittaker et al. (2015) present a relevant review by describing informal volunteerism from different aspects. They introduce the aspect of digital volunteerism in the sub-section "*Digital volunteerism: a new mode*." but do not describe it in terms of co-production. They argue that volunteers bring immense capabilities to the emergency response chain, but these capabilities may be reduced or diminished if they are not integrated into formal structures. Therefore, it is necessary to study how response organizations should design and adapt their structures to integrate citizen volunteers into their response systems (Whittaker et al., 2015).

This literature review explores the emerging knowledge base on ICT-enabled volunteerism in emergency response and crisis management. This is by taking a co-production perspective. Hence, the review aims to answer the question: *what does the literature say about ICT-enabled or digitalized co-production with (digital) volunteers in the emergency response and crisis management field*? The literature review is thus expected to add to the emerging knowledge base by including both large-scale crises and smaller frequent emergencies.

In the context of the review, we use the term *emergency* to refer to small-scale (micro) incidents represented by, e.g., car accidents, while the term crisis refers to a larger (macro) scope, such as earthquakes, floodings etc. In addition, we define *co-production* as the interaction between formal response actors and civil society in terms of involving civilians in designing, producing, and disseminating public services. The citizen's role in coproducing these services may involve physical activities on-site and/or virtual contributions online, e.g., sharing data about a crisis on social media. Consequently, interaction can happen through different channels. Yet, we refer to those digitally enabled as *ICT-enabled* or *digitalized co-production*. Also, the contributions of civilian actors may occur with direct coordination with formal responders or without, i.e., bottom-up formed/organized by citizens themselves. In this review, we include both of these forms of digitalized co-production, including both crisis response and early recovery phases.

BACKGROUND

In this section, we first describe digitalized co-production in the public sector, then connect it to the context of crisis management and emergency response. This is to enable comparisons in the discussion.

Digitalized co-production in the public sector

The increasing extent of contemporary challenges outstrips the capacities of formal actors to design and disseminate efficient public products (Linders 2011). At the same time, the ubiquitous communication possibilities offered by ICTs, change the balance of power between government and civilian actors in favor of civil society (Fraune and Knodt 2021; Linders 2011). That is, citizens have started to co-produce the services previously provided by governments (Brandsen et al. 2018; Linders 2011). Noveck (2015) claims that the ICT-induced power-shifting paradigm leads governments to more legitimate and efficient solutions thanks to involving expertise from civil society. In relation, Lember (2018) describes that governments are closer to the role of a mediator than a pure provider. Thus the power of citizens in public service co-production is undergoing incremental increase, and the role of governments includes developing and facilitating the accessibility of citizens to their e-platforms. That is, through ICTs, citizens develop their bottom-up initiatives and services (Linders 2011).

In relation, Lember (2018) claims that the success of the ICT-facilitated co-production is contingent on integrating the downstream actors, i.e., citizen co-producers, into the implementation phase of digital artifacts they engage with the government through. In contrast to the dominant optimistic view toward ICTs in research, the author urges to expand the research to understand how digital artifacts impact and reshape citizen co-production and -in some stances- limit it. Also, the structure of the co-producing organizations should be upgraded to handle this inclusion proactively and to tackle the accompanied barriers (Lember 2018; Noveck 2015).

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ICT co-production -as mentioned above- is not only contingent on technical capacities; other simultaneous factors should also be handled. Through their systematic review, Clifton et al. (2020) identify the most influential enablers and barriers to ICT-enabled co-production on both the government and the citizen's sides. On the government side, they identify financial factors, e.g., implementing and maintaining ICTs, technical capacities (lack/availability of skilled workforce), and government culture (resistance/acceptance to ICT co-production by staff). For citizen-related factors, the authors introduce technical skills (e.g., lack of technical skills among citizens creates negative attitudes toward ICTs), demographic factors (older people sometimes do not use ICTs), citizen culture (trust in government) and social dynamics (e.g., citizens' resistance to ICT co-production). Yuan (2019) - in line with Clifton et al. (2020)- argues that ICTs have brought substantial benefits to co-production. However, some "dark sides" should be considered and handled, e.g., issues regarding equity, personal privacy, information confidentiality, and misusing governmental data.

Connecting co-production to volunteerism in emergency response and crisis management

Yuan (2019), in his literature review, presents three ICT-enabled citizen co-production models. The first one is *Citizen-sourcing*, through which governments seek to locate expertise among citizens to contribute to public services via online channels. The second model is *Automatic Coproduction*, which employs advanced ICT applications such as the internet of things to flexibly transform data from citizens to public authorities, with almost no active participation from citizens. Finally, the *Government as an Open Platform*; here government outsources the development of public services provision by dispatching public data to a broad audience of technologically skilled citizens to propose efficient solutions. This classification of co-production in public services will assist our argumentation in the discussion section as to the conceptualization of digitalized co-production, whether in large- or small-scale incidents.

RESEARCH METHOD

This section presents the research approach, searching and inclusion processes, and literature analysis.

1- Research approach: Multi-Grounded Theory (MGT)

The ICT-enabled or digitalized co-production phenomenon is emerging compared to conventional co-production. That is why we decided to establish the search processes inductively, i.e., we did not apply predefined criteria to 1- search for literature and 2- code the data. Therefore, the grounded theory literature review approach was deemed suitable for initial inspiration. This gives considerable flexibility to the sampling procedure, enabling researchers to gather data until they attain theoretical saturation when the phenomenon is comparatively novel. Saturation in this manner entails that reviewing more literature will not result in new codes (Wolfswinkel et al., 2013).

However, when we performed data analysis and synthesis, we applied some pre-acquired knowledge, such as categories of co-production by Yuan (2019) and enablers/hindrances by Clifton et al. (2020). Hence, we do not claim an unadulterated application of grounded theory. Rather, we used a deductive, i.e., informed data analysis approach here. Consequently, we applied a hybrid mode of the grounded theory called *Multi-Grounded Theory*; by gathering data inductively and analyzing it (to some extent) deductively (Goldkuhl and Cronholm 2010).

For the research question, we purposefully gave it an open-ended sense to cover all possible aspects relevant to the phenomenon. Also, structuring the paper was essentially inspired by the analysis results and thus allowed data to speak for itself (Webster and Watson 2002; Wolfswinkel et al. 2013). Put differently, it was a common theme among studies to describe formal/civilian interaction in response operations in terms of benefits, enablers, and hindrances, and accordingly, we adopted a similar structure for this study.

2- Searching the literature, defining inclusion criteria, and refining the results

Initially, we adopted the inductive approach to defining our inclusion/exclusion criteria, ensuring an unbiased gathering of resources. That is, we searched using the Web of Science and Google Scholar databases to familiarize ourselves with the phenomenon's state-of-the-art. Having read some pieces of the leading literature, the inclusion/exclusion criteria and the search terms evolved. Since the phenomenon is relatively novel, we used a theoretical sampling approach through which data is gathered until covering the studied phenomenon in question.

The lack of studies about ICT-enabled or digitalized co-production in emergency management was apparent early during data reviewing and analysis. Consequently, after a while, we decided to include works that do not explicitly refer to *digital*, *ICT-enabled,* or *digitalized co-production*. That is, several of the included studies discuss the idea of digital volunteerism in crisis/emergency response but do not describe it in terms of co-production. Hence, we also included this search term. However, only studies that do include *digital volunteerism, ICT-enabled*

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volunteerism, digital co-production, ICT-enabled co-production, or concepts with stemmed and/or synonym words (e.g., digital volunteers) in the domain of emergency/crisis management have been included.

The first search round was conducted on the EBSCO Discovery Service (EDS) database, including the search terms: information and communication technology, digitalization, crisis, emergency, and co-production with their stemmed words and abbreviations. The language was set to English. The time frame is limited to 2006 - 2021. This gave us 121 results; only seven hits met the inclusion criteria, while the remaining 114 were excluded, due to several reasons, such as discoursing co-production in conventional settings, ICT co-production in another field, or taking ICTs as a topic away from the domain of co-production.

Then we implemented another search round inspired by reading leading studies such as Whittaker et al. (2015). We used the search terms volunteer, volunteerism, emergency, information and communication technology, and digital. In addition, we expanded the search for the stemmed words, abbreviations, and synonyms (digitalized, ICT, do it your self government, we-government, etc.). The time range was 2001-2022. We got 91 results, from which 15 hits were selected for further reading and 76 hits were excluded. Furthermore, chain referencing was conducted simultaneously during the review; thus, six studies were included.

In summary, the inclusion/exclusion criteria were set as follows: studies have to describe the interaction between formal and civilian actors, whether as a digitalized co-production mode or as digital volunteerism. Co-production/volunteerism that happens without ICT channels is thus excluded. Intergovernmental organizations (IGOs) and non-governmental organizations (NGOs), e.g., Red Cross, are not considered formal actors in this specific review. The scope includes acute and recovery phases of emergency/crisis response operations, including virtual and physical contributions from citizens (i.e., posting online about a crisis, supporting response teams on the ground, contributing to post-crisis recovery, citizens conducting first response etc.).

In summary, as shown in Figure 1, we adopted 28 works from the first and second search rounds and the chain referencing.
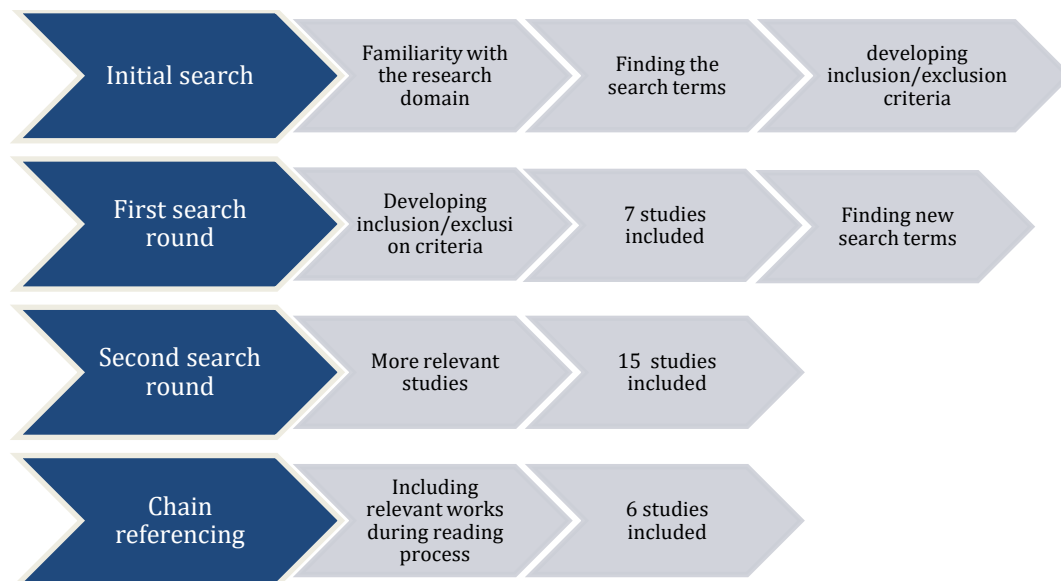

Figure 1. The process of searching for studies

3- Analysis

After searching for relevant literature and refining the results, further detailed reading was conducted. The first coding step also in the MGT approach is open coding. In other words, we did not have a deterministic coding scheme. This since the topic is novel, emerging, and not extensively discussed, and the intention is to minimize the potential for bias. Then, we performed the second step, i.e., axial coding, to develop categories, and finally conducted a selective coding process through which we refined codes and categories and developed themes and sub-themes. As mentioned above, the reviewed studies mostly explore how ICTs have empowered citizen co-production/volunteerism in emergency and crisis response, focusing on the related/triggered opportunities, challenges, and needs.

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RESULTS

We first describe digitalized or ICT-enabled co-production/digital volunteers in large-scale crises, then in smaller frequent emergencies. The overall themes are divided into sub-themes, e.g., importance, opportunities, challenges, and needs. Table 1 presents how the various studies in the review use terms of digitalized/ICT-enabled co-production and digital volunteerism, respectively.

1- Digitalized co-production/digital volunteers in large-scale crises

Some typical response contributions or *services* from civilians during crises include evacuating and searching for victims, posting information about crises on social media platforms, and organizing responses on the ground (Cf. Cobb et al. 2014; Jurgens and Helsloot 2018; Reuter et al. 2020). Also, some volunteers join post-crisis recovery activities, such as rehabilitating flooded houses, disseminating donations, and securing temporary shelters for victims (Cf. Demiroz and Akbas 2022; Mitomo et al. 2013). However, the extent to which civilian volunteers can contribute to crisis response, whether in acute or recovery phases, has been fundamentally changed thanks to the usefulness of ICT applications (Jurgens and Helsloot 2018; Majchrzak and Birnbaum 2011).

As seen in Table 1, the majority of the reviewed studies emphasize social media used by citizens to activate their endeavors to respond to crises. Reuter et al. (2015) consider that recent disasters, which increasingly take a more hazardous nature, demonstrate the need for civilian inclusion in the emergency response chain and the role of social media in coordinating information and organizing volunteers. Batard et al. (2019 p. 2) see volunteerism in this concern as "any freely chosen and deliberate action, be it spontaneous or organized, which is not necessarily formally regulated."

Hence, the effects of ICTs in general, particularly social media, play a paradigm-shifting role by changing the socio-technical fabric of emergency response, thanks to the inclusiveness offered by many-to-many communication systems (Keim and Noji 2011). Through ICT artifacts, citizens can track the whereabouts of emergencies, support the official responders, and help their co-citizens (Demiroz and Akbas 2022). Thus, digital volunteerism can be conceptualized as the online established volunteer activities that emerge using online ICT platforms, i.e., social media and other tools (ibid). Jurgen and Helsloot (2018) present a more open-ended conceptualization of digital volunteerism and consider it as any digitally enabled assistance provided by volunteers, be it remotely implemented or physically on the ground.

Similarly, Purohit et al. (2014) argue that ICT applications have changed how emergencies are managed by amplifying inter-organizational communications and offering citizens an extended share in this management. Social media platforms, particularly, are considered critical communication tools for exchanging information and involving citizen actors in emergencies because they are easy to use, inexpensive, and widely available (Abdulhamid et al. 2021). That is why most scholars in the domain of digital volunteerism have focused on social media (e.g., Abdulhamid et al. 2021; Albris 2018; Demiroz and Akbas 2022; Reuter et al. 2015; Starbird 2013).

1-1 Digitally-enabled volunteerism opportunities and importance

Auferbauer and Tellioglu (2019, p. 218) argue that in response to crises, citizens use ICT applications to establish online "ad-hoc groups" to react to an evolving disaster event. These groups are not fully amorphous entities; instead, civilians establish self-organized units and gather around crises to address the shortcomings that appear on the formal response side, i.e., provide gap-filling contributions (Starbird 2013).

Qu et al. (2009) see that ICTs offer unprecedented *opportunities* to engage civilian volunteers during and after crises. Whittaker et al. (2015) show that digital artifacts, e.g., social media and mapping websites, have enabled citizens to become digital volunteers by easing data production and dissemination. Moreover, the data shared on these groups can be used later in more complex manners, such as data mining and crisis mapping. Cobb et al. (2014) make a similar point by showing that digital volunteers tend, after establishing their initiatives, to collectively organize, locate, and disseminate "actionable" information across their groups to determine upcoming activities. Hence, digital volunteerism is likely to become of increased *importance* worldwide and even function across borders (Whittaker et al. 2015). This ICT-facilitated engagement of volunteers in the official response chain represents a power shift and may be described as a switchboard mechanism. Having this role, volunteers cross the organizational boundaries of response organizations (Albris 2018).

Starbird (2013) illustrates that digital volunteerism is undergoing incremental developments, and volunteer initiatives are becoming more stable and closer to organized forms event after event. Similarly, Demiroze and Akbas (2022) describe that the spontaneous activities of digital volunteers -even though formal responders do not organize them- indirectly impact the latter's first response actions due to the information the citizen actors disseminate throughout their digital groups. Further, they argue that the role of digital volunteers has direct

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positive impacts on society by facilitating self-organizing and collective problem-solving through which emergency victims can quickly request help from their close co-citizens. Mitomo et al. (2013) see that ICT and mass media platforms provide vital *opportunities* to establish recovery volunteer activities and to provide formal authorities with reliable information. Cobb et al. (2014) argue that formal first responders have realized the *contribution* of digital volunteers. Therefore, formal respondents increasingly adopt strategies to empower such initiatives.

The concept of the Virtual Operations Support Team (VOST) is another example of how volunteers' contributions can be utilized. Through a study on the U.S. 2011 Shadow Lake Fire, St Denis et al. (2012) shed light on VOST, which integrates trusted and trained volunteers into the emergency response chain to accommodate data shared on social media by volunteers. In this respect, VOSTs, function by bridging emergency managers with other volunteers who would like to offer virtual and/or physical contributions. Hence, VOSTs increase data utility which can be a matter of accuracy, and coordinate volunteers' activities on the ground, which can fill the gap in organizing volunteers during crises.

Table 1. The studies involved in the review – categorized into various kinds of emergencies and terms used. Those studies that re-occur in crisis and smaller emergencies are highlighted.

	In crises	In frequent emergencies
Digital volunteerism	1. Abdulhamid et al. (2021) **2. Albris (2018)** 3. Auferbauer and Tellioglu (2019) 4. Batard et al. (2019) 5. Cobb et al. (2014) 6. Demiroz and Akbas (2022) 7. Jurgens and Helsloot (2018) 8. Keim and Noji (2011) 9. Majchrzak and Birnbaum (2011) 10. Mitomo et al. (2013) 11. Purohit et al. (2014) 12. Raisio et al. (2022) 13. Reuter et al. (2015) 14. Reuter et al. (2020) 15. Starbird (2013) 16. Webersik et al. (2015) **17. Whittaker et al. (2015)** 18. Qu et. (2009) 19. St Denis et al. (2012)	**1. Whittaker et al. (2015)** **2. Albris (2018)** 3. Ramsell et al. (2017)
ICT-enabled/digitalized co-production		1. Pilemalm (2019) 2. Pilemalm (2020) 3. Pilemalm (2021) 4. Pilemalm (2022) 5. Pilemalm et al. (2016) 6. Ramsell et al. (2019) 7. Paletti (2016) 8. Ramsell (2021)

1-2 Digitally-enabled volunteerism: challenges and needs

Some individuals involved in volunteer groups go beyond the digital spaces they have created/joined responding to an emergency and switch their behavior from collective data exchange to collective actions on the ground (Starbird 2013). However, co-production between professional responders and volunteers is not *risk-free*. First, data disseminated through volunteers' networks might be inaccurate. Furthermore, professionals are surrounded by time pressure and uncertainty under chaotic crises. Dispatching volunteers may put the latter at risk and result in negative outcomes (Batard et al. 2019). Similarly, Auferbauer and Tellioglu (2019) argue that collaboration between different actors during emergency response comes with *inherent challenges*. Thus, ICT-enabled engagement of volunteers may alleviate some challenges triggered by their physical contributions.

Jurgens and Helsloot (2018 p. 85) explain that when volunteers organize themselves using digital artifacts such as social media to provide aid, `"the dynamics change from individual to organizational dynamics."` Nevertheless, some *drawbacks* may evolve, such as data inaccuracy, since many individuals with different backgrounds have established the digital groups and contributed to the data disseminated (Auferbauer and Tellioglu 2019; Reuter et al. 2020). Data can be misleading, and in some circumstances, professional responders can face data overload (Cobb et al. 2014; Reuter et al. 2020). Reuter et al. (2020) state that using social

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media by authorities as a form of co-production is a resource-demanding procedure. Consequently, Cobb et al. (2014) suggest that during disasters, digital volunteers and professionals should collaborate and coordinate in what makes data dissemination easier and more durable.

Also, during collaboration, organizational issues can evolve, triggered by organizational culture and practiced routine, revealing *the need* to improve the coordination ability in the response organizations (Abdulhamid et al. 2021; Majchrzak and Birnbaum 2011). In relation, established organizations' command and control frameworks cannot easily integrate volunteer groups formed using social media (Purohit et al. 2014). Batard et al. (2019) claim that current evidence indicates that formal response organizations have no identified or standard measurements to integrate social media into their back-office IT systems, i.e., to enable tracking the activities of volunteers, enhancing distribution of responsibilities, and ensuring support and safe practices. Reuter et al. (2015) also highlight this, arguing that on-ground emergency managers should be provided with appropriate tools to better track, document, and manifest social media information.

Auferbauer and Tellioglu (2019) see that organized volunteer groups can play a mediator role between formal responders and spontaneous volunteers, e.g., the VOSTs concept introduced before. Nevertheless, to approach more-planned collaboration between formal responders and digital volunteers, both parties must establish predefined schemes that determine responsibilities and tasks to avoid disorganization under response actions (Purohit et al. 2014; Webersik et al. 2015). Moreover, Keim and Noji (2011), mention that current digital volunteerism practices should be integrated into public policies and regulations and that quality assurance should be established.

Webersik et al. (2015), see that to function better, digital volunteers' contributions must be embedded within the structures of formal authorities. Similarly, Purohit et al. (2014) show that regular response organizations have proper training and predefined protocols to deal with various emergency situations, while volunteers have no such advanced capabilities. Thus, response organizations should adopt capable communications that ensure information transformability to guarantee mutual awareness among the involved collaborators. Demonstrating the necessity of adopting tailormade ICT artifacts for emergency response, Reuter et al. (2015) point out challenges and needs related to information flow, distributing activities, and data overload in communication and data exchange.

2- Digitalized co-production/digital volunteers in frequent emergencies

ICT-facilitated co-production embraces frequent smaller emergencies such as traffic accidents, fires, drownings, and heart failures (Ramsell 2021). Here volunteers conduct a wide range of *services* such as fire extinguishing, stopping bleeding, and cardiopulmonary resuscitation (CPR) but also calming victims or sending information to the response organizations. Even though initiatives are mainly bottom-up established in this stance, the concept here usually takes a more organized fashion, i.e., the volunteers are not spontaneous. Rather, co-production is initiated by emergency response organizations, e.g., the fire rescue services (Pilemalm 2021).

Albris (2018) considers some factors that govern the decisions of volunteers to address local emergencies, e.g., emotions and geographical proximity to the emergency. Also, Ramsell et al. (2017), connect ICT-facilitated volunteerism to the term self-government as a variant meaning of co-production when studying the phenomenon in rural settings. The authors identify similar factors that motivate civilians to become first responders, i.e., to shorten response times and strong affiliations to stand for their neighbors. In urban settings, the motivations of volunteers mainly include decreasing response times. (Pilemalm, 2019).

As to ICT, the major difference to crisis management is that the volunteers in smaller emergencies do not seem to lean on social media to the same extent. Rather they are dispatched by professional response organizations and use their own mobile phones. Paletti (2016), presents two examples of applications used to involve citizens in emergency response in the U.S.: *Firedepartment* and *PulsePoint.* By using the applications, volunteers are registered and profiled according to their level of training, to be later dispatched by the emergency operator 911. Similarly, Pilemalm (2020, 2021, 2022) and Pilemalm et al. (2016) introduce an emerging approach to digitally enabled co-production/volunteerism in Sweden. Volunteers receive training from municipal rescue services on predefined tasks/emergency types. They receive alerts on their mobile telephones as short SMS messages or use specifically designed applications, e.g., *Safeland*, *SOS Alarm*. Co-production is thus more planned and coordinated between the collaborating actors than spontaneous volunteerism in crisis management. Ramsell et al. (2017) state that more knowledge is needed to identify what types of emergencies volunteers can respond to, their needs, and the challenges they face. As to social media, volunteer groups sometimes use it, but rather to follow up on an alert/emergency, they went to (Pilemalm 2021). As illustrated in Table 1, the studies on digitalized/ICT-enabled co-production seem to exist only in relation to smaller emergencies.

2-1 Digital volunteers in frequent emergencies: importance and opportunities

Most studies claim that volunteer first respondents are increasingly *important* in a society facing increased large-scale crises at the same time as smaller emergencies continue to occur, all against a background of strained public sector resources (Pilemalm 2020, 2021). The contributions of volunteers are *vital* because citizens are often first at the scene, i.e., closer to the emergency site, especially in rural areas (Pilemalm 2020; Whittaker et al. 2015). Thereby, volunteers contribute to substantial *benefits* in frequent emergencies since they can start first aid before the professional resources arrive. Pilemalm (2020, 2021) describes how civilian volunteers have saved lives on several occasions and argues that they are cost-effective since they cost little compared to a professional resource (thus, they do not have to go on every dispatch or do something useful every time, but a single response may save large amounts of money).

The volunteers may also play an important role in urban or suburban areas in *decreasing burdens* imposed on professional responders resulting from challenges of increased criminality and social vulnerability. Here, cultural diversity and language barriers are among the things that co-production may handle, e.g., volunteers acting as interpreters in the communication between victims and professional first responders (Pilemalm 2019, 2020).

2-2 Digital volunteers in frequent emergencies: challenges and needs

In comparison to large-scale crisis management, the (few) studies on ICT-enabled co-production in small-scale emergencies almost all, to some extent, address *challenges* and *needs*. As to *organizational challenges*, Ramsell et al. (2017) identify unclear legal definitions of volunteering, lack of insurance and basic response equipment, and limited ability to train all interested volunteers due to the lack of personnel. Pilemalm (2020) identifies relevant challenges to suburban areas through a study in Sweden, such as language barriers due to cultural diversity, lack of contribution from women, and present criminality. The author argues that addressing liability and policy issues is more important in excluded areas characterized by high rates of criminality. Further coordination and integration is needed, both at the local rescue services management and national level. Also, integrating volunteers into the ICT systems of response organizations is a significant need. The reason for not tending to this is organizationally triggered by regulative and administrative hindrances rather than technological hindrances (Ramsell et al. 2017).

As to *ICT*, Ramsell et al. (2017), identify several *challenges* triggered by using low-tech ICT solutions. The authors state that since the technology is very simple -represented by alerting volunteers through SMS messages-it only offers one-way communication. Thus there is no way for volunteers to confirm whether they will respond. In addition, this basic SMS solution does not include a positioning function leading to that volunteers will receive alerts even if they are in another area. Moreover, the authors argue that since the SMS technology is not integrated into the ICT system of the public safety answering point, there is no possibility of activating dynamic resource allocation. Thus, there is a need for more optimized dispatch that acknowledges volunteers' competence, skills, and closeness to the incident site, as well as expanded app functions that allow two-way communications (Ramsell 2021). Pilemalm (2020) has studied existing app solutions (with GPS positioning) in urban settings. In addition to the above-mentioned, the author emphasizes the need for a withdrawal function to keep volunteers safe if the situation escalates into something hazardous. The lack of such a function may risk the collaboration form in the long run. Dynamic resource allocation also becomes crucial in urban settings with many alerts to avoid alarm fatigue. In summary, in both rural and urban settings, there is a need to integrate the ICT artifacts into the decision support systems of formal responders to dispatch the right competence to the right task, integrating functioning geofencing and two-way communication functions. Involving the volunteers as end users in developing ICT artifacts is a critical factor in enhancing the abilities of these artifacts and the perception of volunteers (Ramsell 2021).

DISCUSSION

Governments have started to open their structures to external actors/citizens in public service delivery (Noveck 2015; Whittaker et al. 2015). In this literature review, we initially addressed this phenomenon in emergency and crisis response through the lens of digitalized or ICT-enabled co-production. We soon discovered that scarce research on citizen co-production in emergency response exists. In fact, co-production in large-scale crisis management was not mentioned but exclusively conceptualized in terms of digital volunteerism or digital volunteers. This is why we included digital volunteerism in our review as an application of citizen co-production, i.e., when civilians use ICT applications to build up their response initiatives. Below, we discuss the review results in terms of digitalized co-production/volunteerism in different types of emergencies/crises and in an overall public sector context.

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1- The phenomenon in light of the literature on digitalized co-production in the public sector

In line with Linders (2012), citizen ICT-facilitated co-production fundamentally influences public service delivery also in the field of emergency response. The literature review shows how citizen co-production/digital volunteerism in crisis and emergency response has changed, and the role of citizens become increasingly active. By using different ICT artifacts – in particular, social media platforms – citizens are more able to establish their bottom-up initiatives to back response organizations during crises (Jurgens and Helsloot 2018). Following Lember (2018) and Paletti (2016), the review confirms that ICT-enabled co-production can challenge the structure of regular emergency response producers and procedures.

As to the digital co-production models introduced by Yuan (2019), we see that using ICT applications in large-scale crisis management mainly falls under the category of *Citizen-sourcing* due to some similarities with the models: 1- since governments use online platforms during crises to locate expertise and aggregate contributions from a large number of citizens (Majchrzak and Birnbaum 2011; Reuter et al. 2020), 2- governments utilize citizens' online contributions to collect real-time data and information about the crises (Purohit et al. 2014), and 3- volunteers can share different degrees of contributions ranging from virtual contributions, e.g., data exchange, to on-ground operations, e.g., providing first aid for victims (cf. Auferbauer and Tellioglu 2019; Cobb et al. 2014; Jurgens and Helsloot 2018; Raisio et al. 2022).

However, the concept takes a slightly different form in frequent emergencies. Here, citizen co-production is more organized and thus coordinated with official rescue services. By referring to the model of *Automatic Co-production* Yuan (2019), we see a critical mismatch. In automatic co-production, governments rely on advanced technologies and sensors to aggregate needed data with almost no active participation from civilian actors. In contrast, co-production in frequent incidents is based on low-tech solutions that only offer one-way communication, and civilian actors play an *active* role in multiple ways; they receive training and act as first responders. Coming to the third model, *Government as an Open Platform*, the government disseminates data to "tech-savvy citizens" to solve public service provision issues (Yuan 2019 p. 127). Thus, we see that the concept of digitalized/ICT-enabled co-production in frequent emergencies does not agree with either of these models of co-production, i.e., there is a perceived research gap. We initially conceptualize this concept as a *hybrid* form of co-production for two reasons: 1- citizen actors exchange data with official responders and conduct physical activities on the ground (i.e., first aid), and 2- volunteers' contributions are pre-planned by rescue organizations (unlike citizen sourcing, e.g., in crisis response), but these organizations do not formally hire the volunteers (cf. Pilemalm 2022).

Further, in relation to the Clifton et al. (2020) and Yuan (2019) reviews on public sector ICT-enabled co-production, we found substantial similarities as to enablers and hindrances. For instance, in large-scale crises, studies argue how the contributions of digital volunteers should be enhanced by addressing legal issues. This includes the governance of volunteering activities, defining liabilities, and establishing integrative response frameworks (Abdulhamid et al. 2021; Webersik et al. 2015). Some other matters related to data accuracy and reliability of content are reflected in Reuter et al. (2020). The vital role of developing digital artifacts in crisis response is also reflected in the overall literature (e.g., Reuter et al. 2015; Webersik et al. 2015). Furthermore, we came across the resistance of citizens mentioned by Clifton et al. (2020) to ICT co-production in circumstances where official responders impact citizens' initiatives (see. Auferbauer and Tellioglu 2019). As to the organizational challenges, the review shows that digital volunteerism in crisis management becomes more organized event after event. In addition, the analysis reveals the vital role of formal organizations and their staff in supporting the organizations of digital volunteers and processing their inputs to increase their utility, e.g., data exchanged on social media regarding a crisis. This aspect represents two key similarities with literature on public services co-production, 1- by strengthening the capabilities of official staff, the likelihood of technical failures and issues is less "*knock-on effect*" (Clifton et al. 2020 p. 18), and 2- the role of formal authorities becomes closer to a mediator than a pure service provider (Lember 2018).

As a new enabler/hindrance factor, the study reveals the importance of skilled volunteers in integrating new volunteers into the response chain (Auferbauer and Tellioglu 2019; St Denis et al. 2012).

Although the concept takes a more organized character in frequent incidents, it also entitles challenges and needs following Clifton et al. (2020) and Yuan (2019). Some examples are: securing financial and legal support (Ramsell et al. 2017), maintaining ICT artifacts (Pilemalm 2022), and demographic factors, e.g., represented by low contribution by women in suburban areas (Pilemalm 2020), and factors related to technical competence of volunteers (Ramsell 2021). As to dissimilarities with Clifton et al. (2020), and Yuan (2019), the analysis reveals some challenges that are evoked interchangeably by organizational and technical factors that trigger one another (cf. Pilemalm 2022; Ramsell et al. 2017).

Also, we found unique needs and challenges that are specifically relevant to the geography, i.e., implementing co-production projects in rural/urban areas, and needs specific for emergency response, i.e., training, exercises, and

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basic equipment to carry out the first response (Pilemalm 2020; Ramsell 2021; Ramsell et al. 2017).

2- Synthesizing the results of co-production/digital volunteerism in large-scale crises and daily emergencies

This literature review shows that most studies have focused on digital volunteerism in large crises. Fewer have focused on the phenomenon in small-scale settings. Reasons for this difference can be that large-scale crises, when they occur, always attract research and steer research directions. Meanwhile, in all countries, frequent emergencies take many humans' lives and cause substantial human suffering and material damage (Pilemalm 2022). Another potential explanation is the novelty of digitalized co-production and digital volunteerism as a phenomenon. In relation, almost all studies in crisis management described the emerging development as digital volunteerism, while those (few) related to smaller emergencies most often described it in terms of ICT-enabled or digitalized co-production. This may be explained by a limited number of authors re-occurring in several of the studies but also in that this form of collaboration is actually closer to traditional co-production, i.e., the need for governments, response organizations, and volunteers to co-produce the first response.

Thus, one may ask why taking a co-production perspective on emergency response and, in particular, crisis management at all? We set out to do so and ended up with few studies. One might consequently argue that it is unnecessary to introduce the co-production perspective to digital volunteers in emergency response because they, in many respects, refer to the same phenomenon. On the other hand, the literature review clearly shows a similar need for steering, coordination, and integration of volunteers and their contributions – *to co-produce* - also relating to large crises and spontaneous volunteers, both under and following a crisis, and whether they are physically or remotely conducted. Governments currently seem to lack integrative frameworks to cooperate with volunteers formally, e.g., inability to integrate social media into the back-office IT systems of response organizations and difficulties in adopting the concept of volunteerism overall in the command-and-control frameworks. That is, dispatching, organizing, and monitoring volunteers' activities are risky and require fundamental organizational shifts (cf. Auferbauer and Tellioglu 2019; Jurgens and Helsloot 2018). We thus argue that introducing the co-production perspective is relevant for the concept to gain theoretical ground and add to a cumulative knowledge base in emergency response and crisis management. This also enables comparisons as to typologies, enablers/facilitators, and needs and challenges as to the public sector generally. Here, the study demonstrates similarities and differences in how digitalized co-production manifests itself in emergency response, most likely requiring adapted digitlized co-production models.

When extending the scope, including concepts of digital volunteers/volunteerism, the number of studies increased but are still comparatively few in number. This, although we included both small and large emergencies. This can, of course, be seen as a limitation of the literature review. On the other hand, it should simultaneously be viewed as an identified research gap, regardless of if we call it digitalized co-production, ICT-enabled co-production, or digital volunteerism. Given the world's current threats, professional response organizations are likely to face increased challenges of resource constraints and are thus likely to involve volunteers in various kinds of emergencies (Pilemalm 2020, 2021; Ramsell et al. 2019; Whittaker et al. 2015). This reflects the urgency of addressing the research gap as to integrating digital volunteerism/digitalized co-production as a genuine and recognized part -complement, not substitutive- within the formal response bodies. Not least, the global security situation has resulted in many countries re-investing in their civil defense. Here, the ability of governments to mobilize volunteer resources and utilize them in potential wartime also becomes relevant.

Even though we found some differences between co-production in small emergencies compared to crisis response, we see that co-producing emergency response may increase social capital by enhancing the readiness of citizens. Thereby, the technology used for micro purposes may have good potential also in macro scenarios. However, co-production in crises involves somewhat different circumstances compared to smaller emergencies, such as high uncertainty, misleading information, data overload, and challenges in tracking and monitoring volunteers under highly chaotic conditions. That is, in emergency response, volunteers are semi-affiliated; thus, it is easier to predict their engagement. The potential double use of volunteers in various forms of emergencies and what it will require is thus of interest for future research and practice.

CONCLUSION AND FUTURE WORK

Efficient emergency response/crisis management plays a vital role in public safety and resilience and has successively become more open to citizen volunteers, reflecting societal challenges. One enabler is the ubiquitous availability of ICT, which has empowered citizens to establish their own bottom-up initiatives as a response to the challenges professional responders have to deal with. Our study contributes with a literature review where this

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phenomenon is explored from perspectives of digitalized/ICT-enabled co-production/digital volunteerism and includes large-scale crises and frequent smaller emergencies. In line with Yuan (2019), it shows that digital platforms and the benefits of ICTs offer opportunities for volunteerism in emergency and crisis response. However, these digital artifacts will not automatically improve service provision. Rather, activating these benefits requires other adaptations, whether on the governmental, strategic, tactical or operational level. At a theoretical level, we found that none of the Yuan (2019) models agree with how digitalized/ICT enabled co-production functions in small emergencies. In our future work, we will address this research gap by developing an adapted model, i.e., theorizing ICT-enabled co-production in frequent emergencies.

More research is also needed to shed light on the phenomenon both in the large-scale crisis context and in smaller emergencies. Examples of relevant research topics include the applicability of digitalized co-production as a more organized collaboration form in crisis management and the organization of volunteerism in potential wartime. Here, we will explore the potential double use of the same volunteers in emergencies, crises, and worst-case scenarios (e.g., as part of a civil defense). This includes, e.g., what tasks they may perform, how they can be coordinated and tracked and if and when the same ICT may be used, and if/how it must be modified.

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