Could virtual volunteerism enhance information resilience in a nuclear emergency? The potential role of disaster knowledge workers and virtual emergent groups

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Could virtual volunteerism enhance information resilience in a nuclear emergency? The potential role of disaster knowledge workers and virtual emergent groups

Abstract – Informal volunteerism in its various forms is on the rise in the safety and security arena. This study focuses on a new mode of informal volunteerism, virtual volunteerism. The study uses the complex context of a nuclear emergency to explore (1) the extent to which informal volunteerism, in the form of virtual volunteerism, can develop information resilience and (2) the problems and challenges involved. The study relies on interview data gathered from 18 Finnish public authorities and NGO actors working in expert or managerial positions connected to nuclear emergency response. The study results suggest that informal virtual volunteerism could play a role in the development of information resilience in society. However, as suggested in previous studies, virtual volunteerism could be a double-edged sword. There is a real risk of mis- and disinformation because of the volatile times in which we live. The identified risk sparked a debate on the inclusion and exclusion of unaffiliated disaster knowledge workers and virtual emergent groups in nuclear emergency preparedness, response, and recovery.

Keywords: nuclear emergencies / information resilience / informal volunteerism / virtual volunteerism / disaster knowledge workers / virtual emergent groups

1 Introduction

Recent studies have called for greater recognition of the role of informal stakeholder engagement in nuclear emergency preparedness, response, and recovery (see, Geysmans *et al*., 2020; Turcanu *et al*., 2020). Informal stakeholder engagement as used here refers to (uninvited) self-organizing bottom-up activities such as citizens' radiation-monitoring networks, the opposite being the forms of (invited)

formal top-down stakeholder engagement, where authorities decide who is invited and what the influence will be on actual decisions. In the broader context of crisis and disaster research, there is a connection to the concept of informal volunteerism. Informal volunteerism is understood as "the activities of people who work outside of formal emergency and disaster management arrangements to help others who are at risk or are affected by emergencies and disasters" (Whittaker *et al.*, 2015).

One mode of informal volunteerism, and the focus of this study, is virtual volunteerism, that is, volunteering that relies heavily on online digital technologies (e.g. Whittaker *et al.,* 2015; Lachance, 2021). Examples of virtual volunteerism are the actions of unaffiliated volunteer disaster knowledge workers (Smith *et al.*, 2021) and emergent groups relying on virtual means (Reuter *et al.*, 2012). The communicative role of both actors in disaster response has been documented. Whittaker *et al.* (2015) point out that virtual volunteerism is likely to assume a more widespread role in crisis and disaster management, which was already evident during the COVID-19-pandemic (Harris, 2021). Ideally, virtual volunteerism would play a positive role in strengthening the information resilience of societies. Various forms of virtual volunteerism may, among other things, increase the availability of data and facilitate the transmission of information for a wide range of actors in crisis and disaster management (see Sakurai and Chughtai, 2020; Rantamäki and Jalonen, 2022).

The current study utilizes diverse interview material relating to the complex context of nuclear emergency preparedness, response, and recovery (on this complexity, see Geysmans *et al.*, 2020) to explore (1) *the extent to which informal volunteerism, through the mode of virtual volunteerism, can develop information resilience* and (2) *the problems and challenges involved*. The interview data were gathered from 18 Finnish public authorities and NGO actors in expert or managerial positions relevant to nuclear emergency response. The article begins with a comprehensive definition of the concepts central to the research, after which it presents the data and methods used. There follows an analysis

of the observations of the interviewees on the opportunities and challenges virtual volunteerism presents for the development of information resilience. A discussion section connects those results to relevant prior research.

2 Sensitising concepts for analysis

Whittaker *et al*. (2015) identify two broad *types* of informal volunteerism: emergent volunteerism and extending volunteerism. Emergent volunteerism can occur at any crisis stage, is often short-lived, and can be concretized as the action of both group-level (i.e. emergent groups) and individual-level actors (i.e. spontaneous volunteers), both comprising unaffiliated volunteers. Prior research reports that the emergent and informal actors undertake diverse tasks in preventive work, acute situations, and post-crisis recovery. The relevant tasks might involve raising awareness of hazards; opposing initiatives the volunteers believe increase security risk; taking part in search and rescue operations; providing food, drink, and shelter; collecting and distributing relief supplies; contributing to rebuilding efforts; and raising funds for victims (e.g. Stallings and Quarantelli, 1985; Twigg and Mosel, 2017). In the context of nuclear emergencies, emergent volunteerism appears to be implicitly included in the concept of *helpers*. For example, the IAEA report on the Fukushima Daiichi accident states, "Members of the public, referred to as 'helpers', volunteered to assist in the off-site emergency response" (IAEA, 2015).

Extending volunteerism, in turn, refers to volunteering in which actors who do not have an official role in crisis and disaster management (e.g. sports clubs and community associations) extend their activities to the sector (Whittaker *et al*., 2015). The concept includes private sector involvement (i.e. employee or corporate volunteering), which is also on the rise (see McLennan *et al*., 2016). This study, however, focuses more strongly on emergent volunteerism, which emphasizes volunteers' lack

of connection to any underlying organized entity (at least initially), which makes them inherently unaffiliated.

Whittaker *et al.* (2015) also define a new *mode* (i.e. a style or technique) of informal volunteerism: virtual volunteerism. The premise of virtual volunteerism is that "the increasing accessibility of sophisticated yet simple information and communication technologies [ICT] has enabled citizens to participate in emergency and disaster management in new ways" (Whittaker *et al.*, 2015). Accordingly, in addition to physical emergent groups, there are also virtual emergent groups, which "originate in the Internet and mainly carry out their activities online" (Reuter *et al.*, 2012). Similarly, in addition to spontaneous volunteers who converge on the physical site of the disaster, there are unaffiliated volunteer disaster knowledge workers who operate "behind the scenes providing primarily communicative and coordinating support" (Smith *et al.*, 2021). In addition to "pure online volunteering," there are various combinations of traditional on-the-ground volunteering and virtual volunteering (e.g. Lachance, 2021).

Naito *et al.* (2020) describe the Fukushima nuclear emergency as "the first large-scale nuclear disaster to occur in the era of ICT". The impact of ICT was reflected, among other ways, in how people became active on and through social media (see Slater *et al.*, 2012). For example, the emergence of various self-organized and informal radiation monitoring networks is well documented (e.g. Kuchinskaya, 2019; Kenens *et al.*, 2020). Such loosely connected, low-hierarchy networks are described by principles such as open-source, open-data, crowdsourcing, and citizen science (Brown *et al.*, 2016). Citizen science here refers to "a form of science developed and enacted by citizens, with citizen volunteers collecting or analyzing various kinds of data" (van Oudheusden *et al.*, 2019; see also Kenens *et al.*, 2020).

Smith *et al.* (2019) highlight nine diverse tasks that can be included under virtual volunteerism: (1) distributing information, (2) reporting on local conditions, (3) advising others, (4) educating others, (5) connecting people and materials and (6) citizen rescuers with those in need of rescue, (7) trust building, (8) bolstering community unity and strength, and (9) requesting supplies, donations or people to help and assist.

Positive aspects of virtual volunteerism include the fact that participation is often independent of time and place, thus can also reduce the barriers to participation in disaster response (McLennan *et al.*, 2016). Virtual volunteerism also has a communicative role. Ideally, it will support the processes of sensemaking and sense-giving and consequently increase situational awareness in crises and disasters (e.g. Smith *et al.*, 2021). Virtual volunteerism can then play a positive role in strengthening the information resilience of societies. Information resilience can be understood, for example, as the availability of good data and meaningful information and the prevention of problems caused by mis- and disinformation (Rantamäki and Jalonen, 2022). Consequently, strengthening the information resilience of societies could encourage the creation of more mis- and disinformation-resilient societies (see, e.g. Filipec, 2019; Sakurai and Chughtai, 2020).

However, virtual volunteerism has its challenges. While disaster knowledge workers and virtual emergent groups can provide, for example, rich, contextual information, they may also spread misinformation and consequently generate panic or anxiety among citizens (Slater *et al.*, 2012; Sakurai and Chughtai, 2020). Attempting to prepare in advance for virtual volunteerism is also challenging, and as Whittaker *et al.* (2015) point out in relation to volunteered geographic information, "it cannot be known beforehand how much information will be volunteered and where it will come from" and that "the quality of data cannot be guaranteed, with the potential for citizens to intentionally or unintentionally contribute erroneous information". It should also be noted that ICT

may not only reduce but also create barriers, especially for those with limited internet access or who find it difficult to use new digital tools and platforms (see e.g. Radianti and Gjøsæter, 2019).

There is also a tension between the informal, self-organizing nature of virtual volunteerism and "the command-and-control culture" in crisis and disaster management (McLennan *et al*., 2016). The challenge is that overly tight coordination or control generally reduces the agility and adaptability of informal volunteerism (Schmidt *et al*., 2018; Raisio *et al*., 2019; Handmer and Maynard, 2021). For example, the Tōhoku earthquake of 2011 sparked debate over the extent to which excessive coordination and general talk of "unsolicited volunteers" and "nuisance volunteers" may have discouraged spontaneous volunteering in relief activities (see Avenell, 2012; Yūko *et al*., 2012).

Additionally, gatekeeping presents its own challenges. Rantamäki and Jalonen (2022) consider that overly rigorous gatekeeping (of communication) can block the flow of information required to support information resilience. In contrast, gatekeeping that is insufficiently rigorous can encourage the spread of mis- and disinformation. Efficient gatekeeping is fundamentally a balancing act between self-organization and coordination/control (e.g. Simsa *et al*., 2019; Raisio *et al*., 2022).

3 Methodology

This article is part of a larger body of research on the role of the so-called *fourth sector* in nuclear emergencies (limited to nuclear power plant accidents). In Finland, the fourth sector is used as an umbrella term to cover various forms of informal volunteerism, such as spontaneous volunteers and emergent groups (see Raisio *et al*., 2019). Eighteen participants were selected via a purposive sampling strategy to inform the study (e.g. Robinson, 2014).

The identification of potential interviewees relied on the diverse group of participants and stakeholders of the regional preparedness exercise (implemented by the Regional State Administrative Agency in the fall of 2021). The scenario of the exercise dealt with an accident at a nuclear power plant, and the focus was outside the precautionary action zone. The nature of the exercise (a tabletop exercise) determined that the pool of potential interviewees comprised individuals who were in expert or management positions relevant to nuclear emergencies. Relevancy thus implies here that they have a specific role in nuclear emergency preparedness, response, and/or recovery.

Nine interviewees held expert positions, and nine held managerial positions. Thirteen were men, and five were women. Fourteen interviewees worked in the public sector, and four in the third sector. Four interviewees worked at a local level, six interviewees at a regional level, and eight interviewees at a national level. All interviewees were Finns. The interviewees acted as experts on the subject, not as representatives of their organisations. Therefore, to protect their anonymity, the exact background organisations of the interviewees are not presented in the study. However, the interviewees mainly represented safety and security authorities and NGOs, as well as social, health, and food sector authorities.

Semi-structured interviews (e.g. Kallio *et al*., 2016) were conducted remotely, mainly via Zoom, between January and April 2022. The interview protocol included three sections, all addressing the issue of informal volunteerism in general rather than solely focusing on virtual volunteerism (see Appendix 1). The first section dealt with the fourth sector as a phenomenon and concept. The other sections addressed the role of the fourth sector in the different phases of a nuclear emergency and the benefits, problems, and challenges associated with it. Eight of the interviews were conducted after the Russian invasion of Ukraine in February 2022, which affected the content of those interviews.

The average duration of the interviews was 55 minutes. All interviews were transcribed, resulting in 222 pages of text (Times New Roman 12p, line spacing 1).

The data were analysed with an abductive approach to content analysis that encourages moving back and forth between the inductive and deductive approaches during the process of analysis (e.g. Graneheim *et al.*, 2017). The analysis began with familiarization with the data, involving reading all the transcribed interviews several times. Then, the sections in the text that deal with issues and phenomena related to information resilience and virtual volunteerism were identified. This process excluded data on activities that take place mainly on the ground (e.g. decontamination activities) as well as activities where virtual volunteerism has only a coordinating function and where there is no explicit connection to information resilience (e.g. collecting and distributing relief supplies). Next, the selected data were coded into third-, second-, and first-level categories. For example, the third-level categories *raising awareness (before the nuclear emergency)*, *contributing to the public's situational picture (during the nuclear emergency), developing a safety culture (after the nuclear emergency)* formed the second-level category of *transmission of information*. Correspondingly, the second-level categories *transmission of information* and *data generation* formed the first-level category of *the role of virtual volunteerism (in the development of information resilience)*.

As is typical of a qualitative study, the analysis process was iterative in nature. The authors of the article acted as "critical friends" (Sparkes & Smith, 2014) at different stages of the process, encouraging each other to reflect on alternative perspectives and interpretations. The aim was to increase the reliability of the research by implementing researcher triangulation, that is, to ensure that the perspectives of an individual researcher would not be emphasized or produce obvious interpretation errors. The results of the study are described in the next section according to the resultant structure of the coding process. Anonymized direct quotations (#1–#18) translated from

Finnish to English are used in the presentation of the results. With regard to direct quotations, annotations indicate whether the interviewee in question is a public authority or an NGO actor and whether he or she is an actor at the local, regional, or national level.

4 Results

4.1 The role of virtual volunteerism

4.1.1 Transmission of information

The transmission of information was highlighted in the interview data as one of the key roles of virtual volunteerism. In the preparedness phase, this role particularly involves raising awareness of potential nuclear emergencies and how to act in such situations. Raising awareness includes information on the dangers and properties of radiation and the content of home emergency supply kits (including e.g. food, water, and iodine pills) and their importance. The challenge for official communication was considered to be that "*we do not know how to talk about these things in an intelligible way. We easily place too much emphasis on either science or technology.*" (#12, public authority, local level). Virtual volunteerism could facilitate transmitting official information in plain language so that people could better understand the issue.

During the emergency response and transition phases, virtual volunteerism can contribute to the public's situational picture. The role of virtual volunteerism would then develop to encompass sharing information about the nuclear emergency that has occurred: "*[Virtual volunteers] could use social media to convey the right information about what people really need to do now, where they should go, what pills they should take, and, for example, what is the proper way to handle the sheltering or*

evacuation of pets" (#13, public authority, national level). Social media was considered to be a breeding ground for varieties of informal volunteerism, being a place where informal volunteerism, *"lives, breathes and gains more strength"* (#15, public authority, regional level). This is why it was considered natural for emergency management organizations to use informal volunteerism – through the mode of virtual volunteerism – as a resource to convey information, particularly through different social media channels.

Although it was challenging for the interviewees to consider the role of virtual volunteerism in the long-term (i.e. the post-accident phase), they pointed out that the importance of the phase should not be neglected but should be discussed and valued in society more than currently. For example, one interviewee emphasized that in the long-term phase, it would be important to restore things (e.g. preparedness planning) to a better level than before the nuclear emergency. In that case, the role of virtual volunteers could continue to be to convey information and, alongside that, to raise crisis awareness and advance a *"public safety culture"* (#12, public authority, local level).

4.1.2 Data generation

In the eyes of the interviewees, the role of virtual volunteerism should not be reduced to the mere transmission of official information: communication was seen as a two-way exercise. For example, our respondents considered that emergent virtual groups and disaster knowledge workers would have an important role in reporting local conditions. Virtual volunteers would then generate data for the authorities' situational picture: *"But then forming a situational picture, that's what's really important. After all, we can't form a comprehensive situational picture except by collecting that local data"* (#8, public authority, regional level). That data could, for example, include information on the general civic mood, persons at risk, and local needs for mental support. Virtual volunteers would then act to

connect public authorities to what is happening "*beneath the visible surface there in the local community*" (#7, NGO actor, regional level). Such data would otherwise remain hidden, which could subsequently have a negative effect, especially in the long-term phase, with situations (e.g. related to mental health) potentially escalating over time.

The interviews also covered the production of radiation measurement data. It was considered possible that unaffiliated volunteers (for example, self-organizing citizens' radiation monitoring networks) could become involved in radiation measurement activities. This is an example of a combination of traditional on-the-ground volunteering (e.g. collecting data) and virtual volunteering (e.g. sharing data). Particularly those interviewees who represented public authorities saw such self-organizing radiation measurement initiatives as an opportunity if the data collected were reliable and complemented the data collected by the authorities. In general, this was also considered a question of having access to a sufficiently large workforce. If the nuclear emergency affected a large area, "*there would soon be more work to be done [in decontamination and radiation monitoring activities] than there are workers in the authorities or other trained bodies*" (#2, public authority, national level). In addition, the interviewees highlighted how the option to contribute during a crisis might have an anti-traumatic effect. By being active, unaffiliated volunteers could possibly regain even a small part of the control that the crisis took away from them. As one interviewee said with regard to radiation measurements, "*in any case, people would need something to do in this situation, I believe*" (#7, NGO actor, regional level). The threats, in turn, were related to mis- and disinformation, as described in the next section.

4.2 The challenges of virtual volunteerism

4.2.1 Misinformation

Virtual volunteerism was frequently associated with the risk of misinformation. The interviewees meant that virtual volunteers could inadvertently spread false or distorted information. In that case, it is possible that "*more fear than information would be spread*" (#12, public authority, local level). One of the interviewees viewed misinformation as likely to expand rapidly as people became tempted to blow issues or events out of proportion. Interviewees also reflected on how misinformation spread widely during the COVID-19 pandemic, which contributed to their scepticism in the context of a nuclear emergency.

As a concrete example of misinformation, the interviewees considered the various risks of self-organized radiation measurement activities. First, even if the unaffiliated volunteers had good intentions, the reliability of the measurements was considered likely to be problematical: "*Who measures? What do they measure? Are the measurement results commensurate? Are they even true?*" (#14, public authority, national level). The interviewees representing public authorities identified a risk associated with measurement results being published on the internet in the form of open data. The data would then be subject to different interpretations, and different conclusions could be drawn from them: "*If there are even small differences, then people can interpret things differently*" (#10, public authority, regional level). The worst-case scenario mentioned would be the activities of public authorities being driven by false results, leading to a waste of government resources. The respondents warned that public authorities would have to consider well in advance of an emergency how the potentially large data mass generated by unaffiliated volunteers could be processed and how those data should inform conclusions.

4.2.2 Disinformation

In addition to unintentional misinformation, the interviewees also highlighted the risks of intentional disinformation, which was seen to be linked to information and hybrid influencing. In general, informal volunteerism was seen as more susceptible to the effects of disinformation than, for example, formal volunteering. The interviewees identified several factors underpinning that perception. First, unaffiliated volunteers do not have access to the same background information (e.g. intelligence) as organized actors, making it more difficult for them to build adequate situational awareness. A second factor is that informal volunteerism – whether virtual or physical – is inherently spontaneous and unstructured. That unstructured nature means that organizers of an emergency response would not always know precisely who the involved actors are: "*It is a breeding ground for disinformation when it is not clear who we are dealing with*" (#7, NGO actor, regional level). Third, exposure to disinformation was seen to be affected by the fact that not all unaffiliated volunteers may be interested in the work of the authorities or the information they disseminate.

The current international situation was seen as entailing a risk that attempts to influence would be made: "*Apparently, at least in the current tense situation, Finland is on such soil in terms of different interests that these attempts to influence would probably come from outside, and through hybrid influencing, perhaps an attempt would be made to bring about a movement in the [informal] fourth sector, which would then specifically seek to act in the wrong direction*" (#5, NGO actor, national level). The external actors seeking to influence would seek to undermine people's trust in the authorities and use informal volunteerism as an organized actor's tool of power to achieve certain goals. The respondents also raised the possibility that an external party would try to manipulate the open data related to, for example, radiation measurements. That might be achieved directly by manipulating the data through a security breach, or creating scam sites, for example.

Data manipulation would be particularly dangerous in a situation such as a nuclear emergency. The interviewees were aware that, for ordinary people, radiation was abstract, uncontrollable, frightening, and invisible. Therefore, disinformation could have more serious consequences than in less complex situations. As one interviewee stated, "*anyone could put any measurement results out there, and it could create an uncontrollable panic in some area*" (#14, public authority, national level). Nevertheless, the informants did see Finland as having an advantage in the high level of public trust in the safety and security authorities, which was expected to be maintained in the event of a nuclear emergency.

4.2.3 Inclusion versus exclusion

The inclusion and exclusion of unaffiliated virtual and on-the-ground volunteers in nuclear emergency preparedness, response, and recovery attracted much attention among those interviewed. Instead of straight exclusion, a key response to the challenges raised was to suggest that this variety of volunteers is tightly coordinated by emergency management organizations. Including such volunteers would require that informal volunteerism be coordinated in some way. Non-government organizations (such as The Voluntary Rescue Service) would have to largely bear responsibility for that coordination, as the safety and security authorities were not seen to have the resources to do this. In addition to the term *coordination*, the interviewees used terms related to *channelling* in this context: "*I would see it as important that this spontaneous action be channelled so that we can check that it is accurate and reliable. So that we ourselves would then be aware that there is no state influence.*" (#17, public authority, national level) Completely excluding unaffiliated volunteers was, however, seen as an undesirable option. Such action was perceived as likely to cause, among other things, mistrust, reputational harm and, in general, a negative attitude towards the authorities. With regard to self-organizing radiation measurement activities, it was also seen as possible that "*if the*

results are not exploited in any way by the authorities, it may result in the results of the measurements and their exploitation then being captured by that disinformation side" (#2, public authority, national level).

The interviewees also reflected on the extent to which informal volunteerism could be purely self-organizing. However, this reflection remained limited, as the need for coordination predominated. Nonetheless, a few comments highlighted the agility of spontaneous volunteers in a positive sense. One interviewee, for example, pondered providing unaffiliated volunteers with ready-made virtual platforms to which they could deliver measurement data. That same respondent, however, also pointed out that "*the best thing about the [informal] fourth sector may be that they build [these platforms] themselves. In relation to Ukraine, too, it has been seen that suddenly a few innovative guys provide their own sit-rep service. It is a challenge for the authorities that if they do not do it, then (volunteers) will do it.*" (#16, public authority, national level) One of the perceived underlying challenges was that the roles of unaffiliated volunteer disaster knowledge workers and virtual emergent groups had been seen in a negative light by the emergency management organizations during the preparedness activities. For example, the interviewees highlighted how virtual volunteerism had been described as a disruptive activity in preparedness exercises, that is, more of a threat than a positive opportunity. However, it would be possible to see this differently, "*if the situation were that there were a group of people willing to disseminate the correct information, then I think that the [informal] fourth sector would be a resource in communication and not an enemy*" (#13, public authority, national level).

5 Discussion

The results of the study show that informal volunteerism, in the form of virtual volunteerism, is seen by the informants of this study as having a role in the development of information resilience in society

in Finland. This perception is supported by two emerging perspectives in particular. First, unaffiliated virtual volunteers such as volunteer disaster knowledge workers and virtual emergent groups (see Reuter *et al*., 2012; Smith *et al*., 2021) contribute to conveying official information across all phases of the nuclear emergency, that is, the preparedness, emergency response, transition, and long-term phases (e.g. Bertho *et al*., 2022). This is a kind of one-way information broker role. Secondly, virtual volunteerism also makes it possible to generate new data, thus giving virtual volunteers an active role and making communication two-way.

As in previous studies (Slater *et al*., 2012; Sakurai and Chughtai, 2020), virtual volunteerism was seen by the informants as posing challenges that might, in the worst case, outweigh its benefits. The informants were particularly wary of mis- and disinformation, to the extent that there was discussion of the merits and demerits of the inclusion and exclusion of unaffiliated volunteers in nuclear emergency preparedness, response, and recovery (Harris *et al*., 2017). The debate reflects an attempt to balance the extent to which virtual volunteers are included, the extent to which their self-organizing nature is accepted or enabled, and the extent to which safety and security authorities and NGOs should act as gatekeepers (of communication) or coordinators.

This study also confirms previous research findings in the context of nuclear emergencies establishing that coordinated formal volunteer action is favoured by safety and security authorities, while spontaneous uncoordinated volunteers are largely considered a nuisance (e.g. Avenell, 2012; Yūko *et al*., 2012). One influencing factor here is the safety and security authorities' lack of trust in unaffiliated volunteers and in the data they provide, for example, because they do not know the background of the involved unaffiliated volunteers. Trust is, however, one of the key criteria for cooperation between different actors in safety and security work (see Valtonen 2016). In the Finnish context, it is interesting that the public's trust in public authorities is high but that the public

authorities themselves do not seem to have trust in (uncoordinated) unaffiliated volunteers (Raisio *et al.*, 2019). This is partly contrary to the Japanese context, where the impetus for informal virtual volunteerism seems to have arisen precisely as a public response to the perceived institutional inadequacy and the lack of trust in official information (Brown *et al.* 2016).

The key dilemma then seems to be how to enable virtual volunteerism in a way that neither stifles spontaneous action through excessive coordination or control nor facilitates the dissemination of misinformation and disinformation but helps develop high levels of information resilience within society. One possible way to balance self-organisation and coordination/control could be structured self-organization, that is, "to give space to self-organized processes but enable their efficiency by basic structures, clear (although often very short time) goals, and organization" (Simsa *et al.*, 2019). Accordingly, this would not then be an either-or issue, as there would be value in both coordination/control (preventing risks and avoiding inefficiency) and self-organisation (creating agility and adaptivity) (see also Raisio *et al.*, 2022).

This research also has its limitations. First, the wider research project behind the study dealt with informal volunteerism at a general level rather than focusing on virtual volunteerism. Further studies should focus more exclusively on the *mode* of virtual volunteerism within informal volunteerism, which should support obtaining more detailed research results. Second, the study concerned Finland, which has its own country-specific characteristics (i.e. being a small country with a high level of trust in safety and security authorities), which limits the generalisation of the research results. Third, the study's informants represented a limited number of public authorities and NGOs, meaning self-organizing citizen networks (see Brown *et al.*, 2016; Kenens *et al.*, 2020), for example, were excluded from the study. That is an issue that should be addressed in future studies.

6 Conclusions

Recently, the invasion of Ukraine by the Russian Federation has shown that informal volunteerism and the mode of virtual volunteerism is a permanent and growing phenomenon that warrants more attention in research on nuclear emergencies (see Jacoby 2022). Instead of seeing virtual volunteerism as a threat, its potential should also be considered, for example, in preparedness exercises. Doing so early in the preparedness phase could increase associated benefits and reduce risks. The authorities must accept that nuclear emergencies are taking place in the era of ICT, which inevitably affects human action, for better or worse. To conclude, one interviewee reflected this as follows:

> *I've been thinking a bit about that when the Chornobyl accident was – I am so old that I really lived through that time – that if there had been such social media channels as there are now, then what would have gone differently then or if nothing would have.* (#13, public authority, national level)

Appendix 1. The interview protocol

Section 1. The fourth sector as a concept and phenomenon

1. Do you think the fourth sector is a useful concept? Please provide reasons for your answer.

2. How would you describe the fourth sector as a phenomenon in general terms?

3. Have you noticed an increase in the activities of the fourth sector in Finland? Please provide reasons for your answer.

Section 2. The role of the fourth sector in nuclear emergency preparedness, response, and recovery

4. How do you see the role of the fourth sector in *the preparedness phase* of a nuclear emergency?

5. How do you see the role of the fourth sector in *the emergency response phase* of a nuclear emergency?

6. How do you see the role of the fourth sector in *the transition phase* of a nuclear emergency?

7. How do you see the role of the fourth sector in *the long-term phase* of a nuclear emergency?

Section 3. Benefits, problems and challenges related to the operation of the fourth sector in the context of nuclear emergency

8. What benefits can the fourth sector provide in the context of a nuclear emergency?

9. What problems can the functioning of the fourth sector pose in the context of a nuclear emergency?

10. How can one prepare for the presence of fourth-sector actors and working with them in the context of a nuclear emergency?

11. Do you have any further comments on the topic of the study?

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