Using Live Video for Communication between Lay Bystanders and Emergency Dispatchers in Command and Control Centers

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Abstract: Emergency response operations are usually initiated by emergency calls from lay bystanders at the incident scene, providing information that is vital for assessing the situation. While the communication is mainly verbal, the use of live video systems for providing real-time visual information is increasingly being focused. This study presents an analysis of work practices in command and control centers (CCC) in Norway and documents experiences from early-stage adoption and use of a live video system. Based on interviews with emergency dispatchers, our study contributes knowledge on how this new source of information is incorporated in the emergency response decision process in the CCCs. The results show how the use of live video can enhance situational awareness in multi-agency operations, especially in unclear situations. However, the benefits of using video need to be balanced against the additional manual operations required, which may cause delays in time-critical situations.

Keywords: command and control centers, live video support, information collection, situational awareness, normalization process theory, decision-making, emergency management, dual-process theories

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1 Introduction

Successful crisis management depends on the ability of emergency management organizations to collect and handle timely and relevant information, determine the urgency of the crisis, make proper decisions, and perform the right actions. This relies upon the actors' achievement of situational awareness (SA) (Endsley, 1995). The emergency dispatchers at the agencies' command and control centers (CCC) (i.e., fire CCC, medical CCC, police CCC) rely on access to accurate and relevant information from the available sources to build an adequate SA for the specific situation. Several aspects must be clarified before making a decision. This often requires the dispatcher to seek additional information to be able to proceed with the operation.

Previous studies have identified significant information gaps for decision-making during emergency operations (e.g., Bharosa et al., 2009; Van den Homberg et al., 2018). As the verbal information provided by lay bystanders in emergency events can be misleading or limited, emergency dispatchers often need to make decisions based on insufficient SA (Bolle et al., 2011a). Videoconferencing can be used to enhance information collection in CCCs. With video cameras now available in nearly every citizens` pocket (integrated into their smartphones), an emergency dispatcher can utilize the video function to more efficiently build a SA than through voice or text alone (Blum et al., 2014). Further, researchers argue that the use of video may help medical dispatchers to better instruct the lay bystanders remotely to do the right actions for supporting a victim (Johnsen and Bolle, 2008). However, since using a live video system is a novel practice in the CCCs, we have a limited understanding of how live video is being incorporated into the workflows. Therefore, this study aims to answer the following research question: *How is the use of live video systems for data collection incorporated in the emergency response work process in command and control centers?*

To answer the research question, this study investigates the work practices in three different Norwegian CCCs (including medical and fire CCCs), engaged in current projects on the use of live video for communication with callers from the incident scene. The empirical basis for the study is qualitative interviews of emergency responders from the CCCs and expert users of live video conferences, supplemented with an observation of the system in use. The Normalization Process Theory (NPT) (May, 2009) is used as the main theoretical lens, to understand the dynamics of incorporating the live video system and to assess and understand the usefulness of the system. In addition, the study builds on former research on SA and decision-making. The study presents experiences from early-stage adoption and use of live video streaming from lay bystanders in CCCs and discusses how this technology can be embedded in the workflow to improve the emergency dispatchers' SA. Application of the NPT to the emergency management domain can enable a deeper understanding of the normalization process across agencies through focusing on the four dimensions of coherence, cognitive participation, collective action, and reflexive monitoring. As literature shows, the NPT has so far mainly been used in research on healthcare innovations (e.g., Mishuris et al., 2019; May, 2018). Thus, our study also contributes to expand the application of this theory to the domain of emergency management.

The next section provides a background on CCC work practices and the use of live video in CCCs. Section 3 introduces the theoretical lenses for the study, including situational awareness and decision-making, and Normalization Process Theory. This is followed by a presentation of the research approach in Section 4. The results of the data analysis are introduced in Section 5 and discussed in Section 6. Section 7 presents conclusions and implications.

2 Background

This section presents the current CCC work practices, the role of situational awareness and decision-making in emergency dispatching, and the use of live video in CCCs.

2.1 CCC work practices

Studying the work processes of emergency managers is elusive as a result of the diversity in several elements (Baumgart et al., 2008) (e.g., education, training strategy, tools, culture, and procedures for decision-making and agency-specific actions), both among the various organizations and within each organization. In a CCC, several dispatchers with different experiences will often be working on the same emergency event. While the other Nordic countries only have one emergency number (112), Norway has a dedicated emergency number to each of the different first responder agencies (i.e. fire 110, police 112, health 113) (Ministry of Justice and Public Security, 2009). Thus, in multi-agency emergency responses, one of the CCCs is initially contacted by a caller and then has to contact and provide correct information to the other CCCs. In other countries, there are different models of how to organize the use of the emergency number (112) where the Public Safety Answering Point (PSAP) either performs the interviews or forwards the calls to different dispatchers (for example the police for further interview) (EENA, 2019).

The CCCs dispatch the operative unit's fleet consisting of different resources, e.g., ground, air, and water vehicles. Further, they act according to certain protocols and the dispatchers` professional experience. Also, emergency operations require effective information sharing between stakeholders (Salas et al., 2015) and they must provide the relevant information to the right actor at the appropriate time (She et al., 2019). The emergency dispatchers serve as network hubs, and their task is to filter information and decide which information to relay (Steigenberger, 2016). In Norway, this information exchange is governed by different agency-specific protocols and a novel procedure for data collection and sharing that includes all three first responder CCCs, referred to as *the triple alert routine* (Norwegian Directorate for Health, 2019). This is a common procedure for inquiry and action covering nine pre-defined scenarios: bomb threat, fire in a building, acute pollution, tunnel accident, ongoing life-threatening violence, a person in the water, accident at sea, avalanche, and traffic accident. The procedure describes when and how a triple-alert between the first responders should be initiated and implemented.

This novel routine is a response to the need for more common strategies in the CCCs' procedures as there are several similarities in the work processes. *Firstly*, they have the same role in society (see Figure 1). All CCCs function as the public's first interface with the emergency services in an emergency event. *Secondly*, the dispatcher must secure that the important information about the incident is collected by using verbal communication via telephone and possibly search for relevant information in their information systems (IS). *Thirdly*, they must decide on whether the situation requires assistance from one or several emergency services. *Fourthly*, the workflow is guided by protocols for data collection, actions, and guidance in line with the internal systems. This means that the dispatcher must take responsibility to alert resources and response personnel, and exchange necessary information with all parties involved. Nevertheless, in all operations the main goal for the first responder agencies is saving lives, regardless of their distinct focus which is determined by agency and type of incident (National Police Directorate, 2011; Smith and Dowell, 2000). In many European countries, depending on the type of emergency, the dispatchers are reinforced by indexes and interview support (checklists) adjusted to the incident-type protocols (EENA, 2019). In Norway, the medical CCCs use the Norwegian Index for Medical Emergency Assistance (Index) (Nakos, 2018) as dispatch guidelines. The police and fire CCCs also use similar procedures, but descriptions of these are not publicly available.

The CCCs` responsibility does not include leading the operation itself or managing the resources and efforts at the scene of the incident. This is the responsibility of the incident leaders on the emergency site.

However, the CCCs support operative field management and participate in decision-making (Norri-Sederholm et al., 2017). They must follow an operation until measures are terminated, e.g., following an ambulance transport in their GIS until arriving at the hospital.

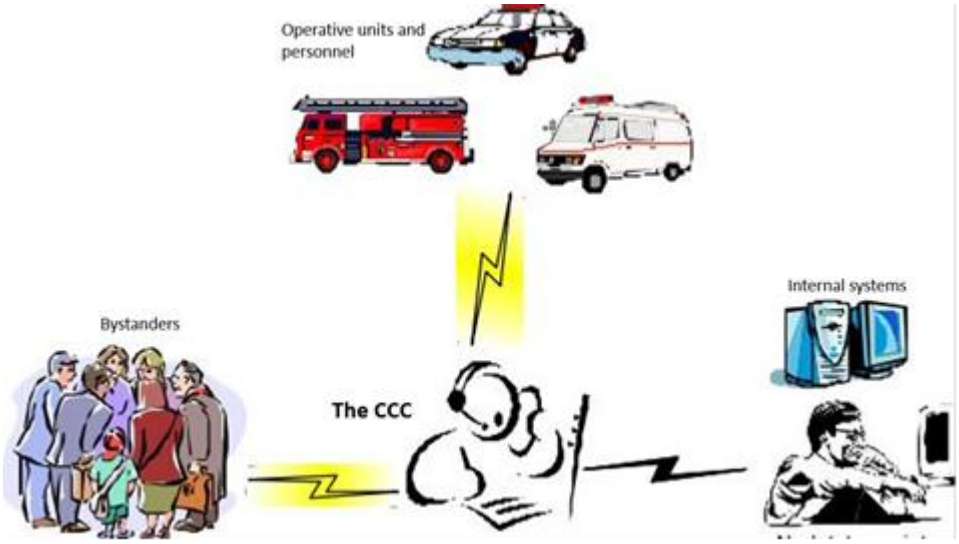

Figure 1: The role of CCCs in society. Adapted from the Ministry of Justice and Public Security (2004, p. 13).

2.2 Use of live video in CCCs

Communication with lay bystanders in crises using video is increasingly focused (Melbye et al., 2014), e.g., in the EMYNOS project (Markakis et al., 2017) involving design and implementation of a next-generation platform to facilitate rich media emergency calls with voice, text, and video. Further, the Next Generation 112 projects (EENA, 2017) conduct testing that involves several European countries. One example is Turkey, where an audio and video module was implemented in the 112 system, enabling face-to-face emergency calls. Bergstrand and Landgrens`study (2009) on live video for information sharing between emergency responders reported that live video provides new capabilities. While documentation on the impact of these projects on the CCC workflows is still limited, some studies report that video calls can introduce new issues such as information overload and privacy breaches (Neustaedter et al., 2018). For example, using video can potentially lead to unintended privacy invasion for the callers as they may get more involved by filming the incident rather than only providing verbal information (Boyle et al., 2009; Park et al., 2016). On the other hand, studies also document that use of videoconference has a positive impact on the interaction between medical emergency dispatchers and lay bystanders (Bolle et al., 2011b; Bolle et al., 2009; Yang et al., 2009) by improving the guiding process between the dispatcher and the bystander. Further, Neustaedter et al. (2018) studied the potential of using videoconference in 911 centers, and the results showed that this could provide valuable contextual information, and help to overcome dispatchers` challenges related to information uncertainty, location, and communication problems.

Emergency dispatchers must remain calm and avoid mistakes while assessing the information they receive during incidents. Approximately one-third of all emergency calls cause peritraumatic stress (Pierce and Lilly, 2012). However, there is still limited scientific understanding of the negative effects of occupational stress on dispatchers (Steinkopf et al., 2018). Literature on this topic also points out that even if the dispatchers do not directly witness the traumatic event, their work is characterized by exposure to tough details from incidents (Gurevich et al., 2007). The stress can also be increased when dispatchers imagine what the lay bystander is telling them (Naustaedter et al., 2018).

The Norwegian fire CCCs are the first in Scandinavia that have access to a common solution for receiving live video (IncidentShare^{TM}) when calls are made to the emergency services number 110. This system has been in use since spring 2019. The implementation procedure for the Incident Share system was demonstrated to the first author in a fire (110) CCC. The system enables callers from the incident scene to stream video and audio directly to the CCC. The dispatcher sends an SMS with a link to the caller, and by clicking on this the caller gives the dispatcher access to the mobile phone`s camera and microphone. Video and audio are then streamed to one of the screens in the CCC. Thus, unlike for closed-circuit television (CCTV), the video streaming requires consent from the lay bystander. It should also be noted that the lay bystander cannot see the dispatcher, hence it is not a face-to-face communication system. The video is recorded and stored locally in the CCCs for a few hours, however, the dispatchers cannot get access to the stored videos after the streaming without consent from the management. It is therefore impossible for the dispatchers to misuse the videos for personal gain.

3 Theoretical lenses

This section introduces the theoretical lenses guiding the data collection and analysis.

3.1 Situational awareness and decision-making

Effective emergency management requires the involved actors to have a continuously updated situational awareness (SA) (e.g., Dilo and Zlatanova, 2011; Endsley, 1990). SA is formally defined as "the perception of elements in the environment within a volume of time and space, comprehension of their meaning and projection of their status in the near future" (Endsley, 1995, p. 36). This definition refers to three hierarchical phases, described as level 1 SA (Perceiving critical factors in the environment), level 2 SA (Understanding what the critical factors mean), and level 3 SA (Understanding what may happen within the situation in the near future). In Norway, the dispatchers build their SA by collecting information using different technologies such as the Norwegian Public Safety Network (radio network), different internal information systems, and Geographical Information Systems (GIS) (Stiso et al., 2013).

An emergency dispatcher`s need for information that supports SA is naturally narrowed down to elements that are important to reach their professional goals. Attention to the elements that are important for the specific situation is crucial for effective decision-making and response (Endsley, 1999). Because of the limitations in human information processing capabilities (Endsley, 1999; Lamb, 1991), the attention of humans tends to be selective. This increases the risk of using energy on some parts of the available information at the expense of possibly overlooking other more important information. Through training and experience, emergency dispatchers can quickly identify suitable patterns in specific situations from only partial information (Kinsey et al., 2019). In these cases, the actors react to their professional experiences, also known as a Recognition-Primed Decision (Klein et al., 1993). However, this intuitive judgment may have lower accuracy and is prone to systematic biases (Kahneman and Klein, 2009). This is related to the dual-process theory (e.g., Sun, 2001), that recognize *system 1* and *system 2* in human information processing. The automatic system (*system 1*) is initially used in the decision-making process, and the reflective system (*system 2*) enables humans to address events in a more calculated manner and requires more information to complete the decision-making. However, when the dispatcher receives too much information, this can exceed human cognitive capabilities and result in information overload. To deal with this, there are decision support systems for information sampling, decision-making, and response execution, such as the triple alert routine. There are positive effects of such systems (Yoon et al., 2008). Different decision support systems are applied by emergency responders worldwide and have become popular in telephone-based services in healthcare, such as for the dispatch of ambulances. These systems combine expert knowledge with algorithm-based rules that facilitate decisions and measures (Pope et al., 2013). Decision support systems are also used in the police and fire services. For example, in the US the

Emergency Police Dispatchers (EPDs) are using the Police Priority Dispatch System (PPDS) (Broadbent et al., 2018) and Emergency Fire Dispatchers are using the standardized Emergency Fire Dispatch (EFD) protocol-based system (Purvis et al., 2020).

3.2 Normalization Process Theory (NPT)

To extract the benefits of new information sources such as live video streaming into the CCCs, it is important to investigate how technology intervenes with existing workflows. The Normalization Process Theory (NPT) (May, 2006; 2009) is chosen as the theoretical lens for the empirical data collection and analysis to determine whether there are any workflow issues when implementing novel systems for information collection in complex work environments such as the CCCs. Further, in this context the NPT helps to identify the usefulness of the system and whether it justifies the effort of using it. The NPT deals with "*how and why things become, or don't become, routine and normal components of everyday work*" (May and Finch, 2009, p. 535). It emphasizes the need for a theory-driven approach to new practices that require complex changes in clinical routines (Grol et al., 2007) because a theory can provide universal and transferable explanations.

Since the use of the video system is not embedded in any procedures or integrated with the operative systems in the Norwegian CCCs, the focus in this paper is on how the dispatchers cope with the new system. The core focus of NPT is the work that individuals and teams do to facilitate an intervention to become part of their everyday routine, and thus be normalized. However, the normalization of systems implemented in different domains can also be denormalized (Murray et al., 2010) because they simply do not fit into the organization's workflows. The NPT defines four domains for investigating the intervention in the workflows, which in this context refer to the following processes undertaken by the dispatchers in the CCCs (adapted from McEvoy et al., 2014): (1) *Coherence*: the required sense-making process to favor or hinder the routine embedding of the use of live video streaming; (2) *Cognitive Participation:* the process to engage in the new practice of using live video; (3) *Collective Action*: the work the dispatchers have to do to enact the new practice; (4) *Reflexive Monitoring***:** the work to assess and understand the video streaming system`s effect and usefulness.

4 Research approach

To answer the research question, we conducted a qualitative research study using an interpretive approach (Walsham, 1995). This facilitates an in-depth understanding of using live video in a real-life context and hence contributes to the body of knowledge by investigating the technology in a natural setting (Mueller and Urbach, 2017).

The data collection included interviews, observation, and review of publicly available documents. A semi-structured interview guide was developed, including open questions categorized based on the four domains of NPT and an additional Context category (May et al., 2016) for mapping the workflows in the CCCs. The population in this study was Norwegian emergency dispatchers (from fire and health CCCs) with a special role as experts on the use of live video in their workplace. Since the use of live video in CCCs is novel in Norway, the number of relevant CCCs to contact was limited. The managers in three CCCs using live video were contacted for getting access to expert users that could participate in the interviews, thus a purposive sampling technique was used (Etikan, 2016). Interviews with expert users in two fire CCCs and one medical CCC were conducted (see Table 1 for a selection of themes/questions). An expert user typically has received more training in the system and is given responsibility for supporting colleagues in their use of the system. Given the limited availability of public documents that describe the routines in the CCCs (ref. Section 2), an additional interview was conducted with a dispatcher from a medical CCC that is not yet using live video streaming. This interview contributed to the data collection on the daily

workflows in the medical CCCs. The interviews lasted 40-50 minutes and were conducted either physically or using a digital platform (e.g., telephone, Skype, Teams) due to the Covid-19 pandemic. The interviews were recorded and transcribed in full.

Table 1: Examples of themes/questions from the interview guide.

Question category	Examples of themes/questions
Context	Please describe your organization (aim, tasks, protocols, routines, etc.), and your role and tasks. How do you handle an emergency incident? How do you use your procedures (algorithmic, indicative, etc.)?
Coherence (i.e., meaning and sense-making by participants)	What (if anything) do you think the live video system provides regarding data collection and situational awareness? Other issues? How does the use of live video fit with your existing data collection routines? What advantages and disadvantages does the system provide?
Cognitive participation (i.e., commitment and engagement by participants)	What did you think about introducing live video as a data collection tool in your workplace? Was there any resistance when introducing it? What direction might be desirable for the future use of the system?
Collective Action (i.e., the work participants do to make the system function)	How does this system affect your work routines? Does the system give you the flexibility to do actions on your own? Does the system provide a better basis for making decisions? Please give an example from practice.
Reflexive Monitoring (i.e., participants reflect on or appraise the system)	What do you think about the effects this system has on your organization? And the collaboration with other organizations?

The observation took place in one of the fire CCCs where the system was demonstrated and discussed in the CCC workspace. Two emergency dispatchers here showed how they use the system and answered questions. In addition, an audio log from a medical CCC was collected as an example of the use of dispatch guidelines in the initial phase of a response operation.

A review of publicly available documents was also conducted with a focus on understanding the basic workflows in the CCCs. Also, an evaluation report from a pilot project on the use of a live video system in four medical CCCs (Kramer-Johansen et al., 2020) was reviewed.

The data analysis required the authors to make sense of the collected data (Creswell, 2009) and was done in two iterations. The interviews were translated from Norwegian into English, and further coded in NVivo (QSR International). First, the coding process used the interview guide as a foundation for defining themes within the different NPT domains (Table 2). The interview statements were manually coded into the four NPT domains, the Context category, and features related to situational awareness. All themes were related to the use of live video in the actual NPT domain, based on the informants` reflections and examples from practice.

Table 2: NPT domains used for the initial analysis process.

Domain	**Themes**
Context	Workflows, procedures/structures, description of various systems, the use and interoperability, and additional systems
Coherence	Impact on SA, barriers, thoughts on use and functionality, sensemaking of the system, advantages, trust, organizational goals
Cognitive participation	Collective thoughts on implementation, use, how the system was introduced, resistance, future development
Collective action	Influence on workflows and caller interaction, required knowledge, flexibility, collaboration, additional information, decision making, actions, trust
Reflexive monitoring	System`s effect on current and previous practices, procedures

Second, an inductive method was used to code the data included in each theme into different stakeholders` perspectives and similarities and dissimilarities within each theme. Selected quotes from the interviews that underpin the results are presented in the Results section.

5 Results

This section presents the results of the data analysis. First, we present an overview of the day-to-day workflows in the four Norwegian CCCs studied. Then, we summarize the stakeholders` experience using live video systems for data collection and interaction with callers from the public. Finally, we present how the use of such live video streaming for data collection in the CCCs affects the dispatchers` SA. Section 5.4 presents a summary of the results.

5.1 Context

From the analysis, the following four aspects of the workflows seem to be common for all CCCs interviewed: agency-specific procedures and tools, triple alert routine, and documentation. This shows that the work tasks are relatively similar which can be a result of the triple alert routine. Of course, the CCCs still have different tasks and goals in various situations (Steen-Tveit, 2020), and most emergencies they handle are agency-specific. However, the results of this study show that the workflows are quite similar across all CCCs. For instance, they all start with the same initial collection of critical cues by talking to lay bystanders using verbal communication on the telephone. A “starting card” is an example of the medical CCC`s formalized initial critical cue collection (referred to as Index). The excerpt below is an example of an initial critical cue data collection between an emergency dispatcher (ED) and a caller, taken from the example audio log:

ED: *Medical emergency phone*
Caller: There *has been a traffic accident..a car is outside the road!*
ED: *We are going to help you. Where are you?*
Caller: *It is in Lillesand municipality on highway 34.*
ED: *It is in Lillesand municipality, is it by Glamsland?*
Caller: *Yes*
ED: *We will send help*
Caller: *That’s good, I think it's urgent.*
ED: *What is the phone number you are calling from?*
Caller: *Ehhh…it is xxxxxxxx*

ED: *How many cars are involved?*
Caller: *There is only one car*.
ED: *How many people are in the car?*
Caller: *Eh, there is someone hanging upside down*.
ED: *Someone is hanging upside down.. are there more people in the car*?
Caller*: Ehhh*..
ED: *Are there any others in the car?*
Caller*: No, and he is not awake*.

Notice, the dispatcher asks about the number of people in the car repeatedly until she gets an answer to the question. As one of the respondents puts it:

"*We answer the emergency call and map the situation by using the starting card; where the patient is, their telephone number and if the patient is awake and breathing normally.*" (Medical dispatcher)

The fire CCCs do not have any written initial critical cue collection tool such as the starting card in Index. However, they mentioned that all action cards (i.e. manual decision support) in the national triple alert routine start with "starting questions" and are directly followed up by "common clarifications".

"After we implemented the national triple alert routine, I feel that things are more systematized." (Fire dispatcher)

Concerning the agency-specific procedures, the two fire CCCs solely used the triple alert routine.

"*Now we have implemented common action cards* [e.g., based on the triple alert routine] *with the medical and police CCC, which I believe is more similar to the medical CCC Index. This is actually a book that you turn to for the actual incident type, and then you will be guided through what kind of questions you must ask.*" (Fire dispatcher)

The other respondents explained that incidents that are not included in the triple alert routine are mostly handled based on the dispatchers` experiences.

All CCCs document the important information in writing and register the measures taken in their incident management systems which also serve as a written communication to the operative units.

5.2 Using live video in everyday work settings

The questions informed by the NPT aimed to understand the dynamic processes that lead to the embedding of the live video system into the CCC workflows. This section is organized according to the NPT framework and the Context category.

Coherence involves the sense-making process the dispatchers have to go through to favor or hinder the routine embedding of the use of video streaming. Firstly, the dispatchers need to be aware of how they understand the actual difference between the data collection by verbal communication only, versus using both verbal and visual communication. This includes the knowledge and practice on when to set up the video and when not to. The time it takes to set up the video must not delay the proper reaction to the situation. As stated by one dispatcher:

«You cannot use video for confirming whether a patient is breathing properly or not. Any uncertainty on this would require a red (acute) response.» (Medical dispatcher)

When the respondents were asked if they knew when to use the live video and not, they emphasized that the system must not slow down the response. As there is yet no established procedure for when to use the system, the dispatchers must decide on this in each situation. When discussing the idea of implementing the system, the fire respondents were somewhat reluctant:

"It is a new system, new and different and it requires to do more actions than you really need to do." (Fire dispatcher)

Likewise, the medical respondent expressed mixed experiences. The issues raised included tough visual impressions from the incident site for the dispatchers, that it was time demanding, and that it requires extra operations in their workflow both technically and for getting informed consent from callers. But overall, the medical respondent regarded the system as a forward-looking feature for their operative work, providing value in several cases. The participants considered the video streaming system to be a natural extension of their work practices. The medical dispatcher points to that most people today are familiar with the use of the camera on their mobile phones, resulting in a low threshold for responding to live video calls.

These results are also supported in the evaluation report specific to the medical domain. For example, the evaluation showed that the total time for the response can be increased when using live video, that live video can be an advantage during the guidance of bystanders, and that the visual impressions could result in increased mental strain for the dispatchers.

Cognitive Participation refers to the dispatchers' relational process of building a new practice of using live video. This means that it is not only about individual commitment but also about building communal engagement. The respondents here expressed that age and number of years in the profession also should be taken into account as factors influencing communal engagement:

«*I have an impression that it is us, the young people, who think this system is exciting to use.»* (Fire dispatcher)

The enrolment of the actors that are required to make the system work is somewhat diverse between the CCCs. While use is more widespread in the fire CCCs, the usage in the medical CCC is more heterogenous:

«I think the system is a good idea, and that it is necessary. But I am surprised that not more of my colleagues have chosen to use it. Looking at the numbers this week, it was used in only 34 calls out of the several hundred calls we get in one week and sometimes even in one day». (Medical dispatcher)

Collective Action relates to the dispatchers' operational work to establish the new practice. The interactional workability of the system, i.e. the collaborative work that the actors do to operationalize the system so it can be embedded into everyday settings, is a key feature that both the fire and medical CCCs underpin. The respondents describe an increased focus on the system recently, with management encouraging the dispatchers to provide more feedback on how the system can contribute positively to their assessment in different situations. For example, the dispatchers need to have confidence in what the images from the live video represent and thus have to build an understanding and a culture in the CCCs to trust the information they get from the video:

"We have a professional view on the situation, and the callers are ordinary lay bystanders. They can observe a car fire…., they over exaggerate. And then we can see that it is only steam from the radiator. …. People have a great fear of fire – "it has to be extinguished!" People often put themselves in danger to do this. So we gain a lot of understanding by being able to see the incident site." (Fire dispatcher)

As ilustrated by this quote, the fire dispatcher must be able to trust what s/he sees and promote that one can trust that the image actually represents the real situation. The question above is whether the smoke really is steam from a radiator and not from something else, and whether it is safe to trust and provide advice based on that information. If not, using video would only increase the workload because it will not provide valuable information, just images in addition to the verbal information. On contextual integration, i.e., how the system works with their protocols and workload, the following response was given:

«In general, our alarm central is in need of more resources. For example, one weekend was extreme with me having to respond to 150 calls in one hour and 21 of these requiring red (acute) response. We are only two people serving all calls, and with 21 red responses in one hour (in addition to all the other calls) you do not have time to connect the video system. And it does not work to be «stuck» in a video so that you have to park incoming emergency calls.» (Medical dispatcher)

The respondents explained that the video system is not yet an integrated artifact into their operative information management system. This provides more work operations and might cause delays.

Reflexive Monitoring refers to the understanding of how a new set of practices affect their work. The informants explained how they gave attention to the need for adjustments for the system to fit into their workflow. For example, in the medical CCC they had provided the dispatchers with a written reading list for the instructions they had to provide to the callers when connecting the video. Also, they were in the process of making a procedure that gives additional references for their use of the system.

"The reading list is in our intranet and you can click to see this for support if you need it (…) we have seven screens so it is possible to have quite a lot of procedures visible." (Medical dispatcher)

The fire CCCs had a more implicit structure for use, where the live video would only be used when the information from the verbal communication was not sufficient. Further, there was a continuous reflection on when to use the system, rather than whether it should be used.

Another issue raised was how receiving live video from the incident scene sometimes could cause emotional stress for the dispatchers:

«Some report that they [*through use of video*] *have got visual impressions that they have not been prepared for, and that they really would have preferred to be without.»* (Medical dispatcher)

5.3 Features related to SA

Emergency dispatchers` SA is highly dependent on the information provided by the lay bystanders (Linderoth et al., 2015). The respondents talked about how the video system supports their SA in several ways: (1) the dispatchers can use the system to assess if this is a situation to respond to at all; (2) they use the system to evaluate the degree of different situational elements (e.g., the severity of bleeding, the color of smoke); and (3) they use the system to get an overview of the context and adapt measures and advice according to what they see. The following answer illustrates the above-mentioned points:

"I think it affects our situational awareness a lot because we have probably sent a lot more resources than we might have needed at some incidents before, where it turned out that "wow, why did we send in this situation, it was nothing". So it helps us in terms of resource use and whether it is an event at all." (Fire dispatcher)

5.4 Summary of the results

Table 3 provides a summary of the results divided into context, the four NPT domains, and situational awareness.

Table 3: Summary of the results.

Category	Results
Context	• Four aspects of the workflows are common: agency-specific procedures and tools, triple alert routine, and documentation. • Medical CCC has written initial critical cue collection in addition to the triple alert routine, as opposed to the Fire CCC which in cases not included in the triple alert routine uses the dispatchers` experience.
Coherence	• The time it takes to set up the video must not delay the prompt reaction to the incident. • There are no established procedures for when to use the system. • The system requires more actions for initiating use. • The video streaming system is considered to be a natural extension of the existing work practices. • The system can provide mental strains related to visual impressions.
Cognitive Participation	• It is considered positive that live video has been implemented as an option in the CCCs. • There is still a limited number of dispatchers that use the live video. • The youngest/less experienced dispatchers in the Fire and Medical CCCs seem to be using the live video most.
Collective action	• The collaborative work that the dispatchers do to operationalize the system is a key feature that both the Fire and Medical CCCs underpin as important. • There is an increased focus on the system, with the management encouraging the dispatchers to provide more feedback on how the system can contribute positively to their assessment in different situations. • It is considered important to have confidence in what the images from the live video represent and to build an understanding and a culture in the CCCs to trust the information from the video. • The video system is not yet an integrated artifact into their operative information management systems. This provides more work operations and might cause delays.
Reflexive monitoring	• Attention is given to the need for adjustments of the system to fit into the workflows. • A procedure is currently being developed for providing the Medical CCC dispatcher with more guidance for use.
Assessing emergencies/ SA	• The video system supports the dispatchers` SA through the ability to assess if the situation requires a response at all, evaluate the degree of different situational elements (e.g., the severity of bleeding, the color of smoke), and get an overview of the context and adapt measures and advice according to the visual information.

6 Discussion

The discussion section will consider the results related to workflow, the four domains of NPT (coherence, cognitive participation, collective action, and reflexive monitoring), and SA features.

6.1 Decision support systems in CCCs

The results show many similarities in the three CCCs' workflows despite their different domains of emergency management. The workflows in common operations are more similar than during agency-specific operations because of the use of the decision support system triple-alert routine. This type of decision support system that guides the dispatchers` data collection can help to avoid information overload and assist the cognitive dual processes by guiding the dispatcher into using the reflective system in cases where the composition of the initial information is not entirely obvious. The workflow is closely connected to the three levels of SA, where the dispatchers first collect cues for level 1, then assess these based on agency-specific protocols and experience to gain an understanding of level 2 and level 3 SA (Figure 2). Based on the interviews, some situations demand that the dispatchers must continue to collect additional data by for example asking more questions, searching in different information systems, calling other experts, or connecting to the video system (ref. Figure 2). Consistent with the literature on the dual-process theory (Sun, 2001), this means that the dispatchers need additional information and have to activate the cognitive reflective system (system 2) to address the situation. Based on the respondents' answers, the live video system appears to be a good tool for collecting additional data for enhancing SA. Ideally, the initial response and video streaming could be activated in parallel in some scenarios such as during dispatcher-assisted cardiopulmonary resuscitation (T-CPR) (Johnsen and Bolle, 2008). However, the results from this study show that because of limited resources in the CCCs and the additional workload required for setting up the live video connection, the system is used only when it is considered necessary for deciding on *how to* respond. Figure 2 illustrates how the live video system is used in today`s practice. The probability for parallel response and live video connection is likely to increase in the future when the live video is fully integrated into the existing information systems and procedures.

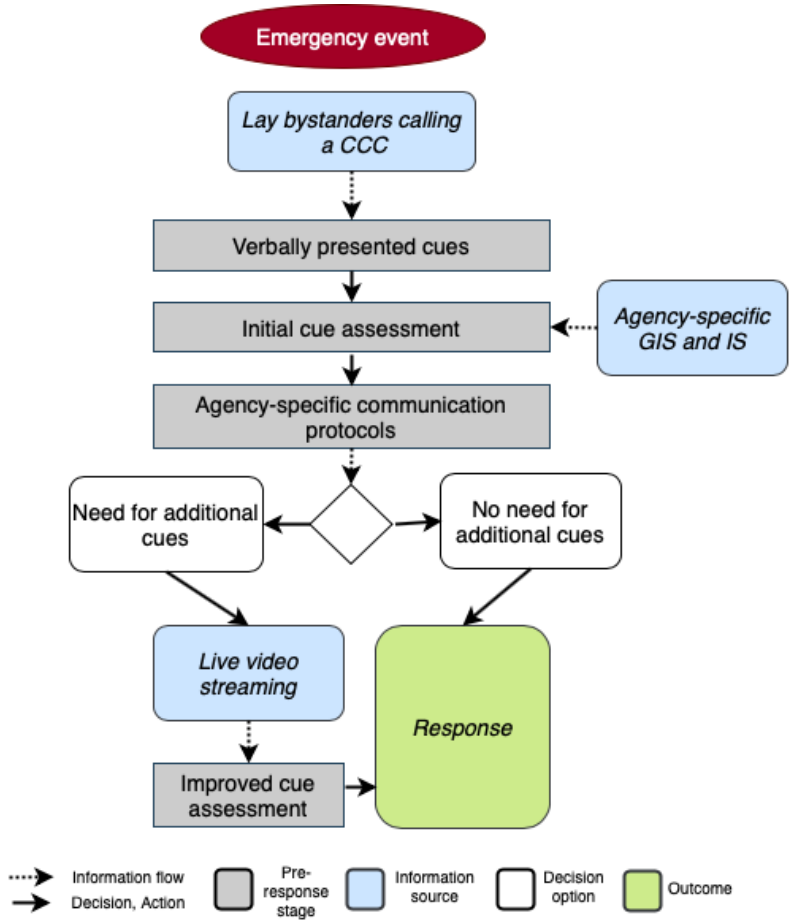

Figure 2: Incorporation of live video in the decision-making process in CCCs

Using live video for communicating with lay bystanders represents a novel way of collecting data for enhancing Norwegian dispatchers` ability to gain SA in emergency events. Since the workflows in the CCCs are relatively strict and dependent on different events and procedures, a new source for information collection must fit into these delicate work patterns. First of all, the dispatchers have a choice whether or not they should set up a video in various situations. In the *coherence* domain of the NPT, our informants argued that the video system is overall a good idea to implement, however, the time it takes to set up the video must not delay the proper reaction to the situation. This relates to the initial critical cue collection that activates the cognitive automatic system, enabling immediate response based on experience. Consider here the example mentioned by the medical dispatcher: if the patient does not breathe properly, you cannot waste any time on figuring it out. If the dispatchers assess the situation as obviously time-critical and life-threatening, the only right thing to do is to follow the agency-specific protocols and perform the defined actions with absolutely no delays. However, many situations are difficult to assess due to various issues. For instance, as highlighted by several informants, the interpretation of the severity of the situation can be quite different between dispatchers and lay bystanders. As mentioned in Section 2, video support can be a valuable tool to minimize such challenges by providing contextual information and ease communication problems (Neustaedter et al., 2018). This may especially be relevant in incidents where all three CCCs must be involved, such as the scenarios in the triple alert routine. In these scenarios, the data collection must cover all CCCs` information needs to assess the situation for making proper actions. This represents a challenge given the heterogeneous information needs among the organizations involved (Bharosa, Lee, & Janssen, 2010) A study by Singhal and Neustaedter (2018) noted that video calls provide a positive effect reported from lay bystanders because they can show rather than tell dispatchers about a situation. This can lead to a quicker way for all the involved CCCs to gain SA instead of covering all information needs solely by a verbal interview of the lay bystander. For example, using video in the avalanche scenario in the triple alert routine seems advantageous, since this scenario requires quick access to complex information (e.g., visibility, degree of danger, implemented measures) (Norwegian Rescue Services, 2018) that may be difficult for a lay bystander to convey effectively. However, one must consider that the interpretation of the images does not necessarily represent reality as the nuances and context will not always be correctly captured or represented. The technology may not be able to capture the nuances in poor light or weather conditions, such as in an avalanche scenario.

Deciding when the system should be used is affected by the various practices among different dispatchers. This can be considered as part of the *cognitive participation* domain. The respondents answer that some dispatchers do not use the system at all, partly related to their length of experience and age. For instance, one of the respondents told that some of the well-experienced dispatchers thought that they knew well how to assess emergency calls and thus had no need for video support. Another reason is that the video system requires additional operations in the digital workspace. Further, it is not included as a mandatory tool in any of the protocols but rather as an optional alternative in all cases. Johnsen and Bolle (2008) found that it is necessary to adapt the protocols to include the use of the video system, and it could thus be beneficial to insert a "consider the video in specified cases" measure. This leads to the *collective action* domain where some of the beneficial consequences of using the system were described. In many cases, the lay bystanders have no prerequisites for assessing the situation, and the dispatcher's task is to guide them and provide proper advice. An example from the interviews is that the dispatcher saw a person putting himself in danger by climbing into a burning truck to try to extinguish a fire. This illustrates a situation where the dispatcher`s advice can rescue lives by receiving visual information. Nevertheless, the dispatchers must be able to trust the information they receive. As in the example where the dispatcher characterizes the smoke as steam from a radiator, it is important to consider if this assessment is correct. Relating this to the *reflexive monitoring* domain, all of the CCCs had ongoing discussions on how to take the benefit of the system in the best ways possible by embedding the system into their practice and workflows.

Previous research shows that the users of mobile video devices (e.g., smartphones) do not necessarily consider privacy issues (Procyk et al., 2014). Using live video during emergencies raises important privacy

concerns (Boyle et al., 2009; de Vasconcelos et al., 2009). In public settings, bystanders may not be comfortable with being filmed. For example, their location and activity are elements reported to be an issue, however, with stronger concerns stated for video recording than streaming (Singhal et al., 2016). A solution that might be relevant is automatically masking out lay bystanders.

6.2 The effect of visual input

The respondents repeatedly mentioned how the video system affects their SA. For example, the visual input affects how they manage resources in different scenarios, which could save both economic and human resources by avoiding unnecessary response actions and making these more available for critical incidents. Today, the dispatchers mostly respond based on verbal information solely, thus, the visual information can better convey the complexity of the situation as the description given by bystanders might be lacking or misleading (Bolle et al., 2011). Further, the answers suggest that it might be easier to see the situation as a whole during complicated conditions, such as in complex multi-agency scenarios involving communication problems with bystanders or information ambiguity (Neustaedter et al., 2018). The possibility for sharing the same video stream between the CCCs, for example as a part of the triple alert routine, is considered an opportunity for facilitating a common SA. Because of the agency-specific information needs, one can assume that the possibility to assess visual information is beneficial for an initial operation. In this way, the agencies can simultaneously obtain the information that is important for them. However, the video system`s increased effect on the SA also has a side-effect; by only using verbal communication, the dispatchers are protected against distractions from the visual impressions, and the mental strain that these visual impressions may provide in many emergencies. Some dispatchers had reported that the use of video had given visual impressions that they have not been prepared for, and that they really would have preferred to be without. In the worst case, the visual impressions can amplify the stress caused by the tough details provided by lay bystanders as the dispatchers now actually are direct witnesses of the traumatic events. On the other hand, the dispatchers will no longer only imagine what the lay bystander is telling them and instead have a real-life image.

Based on the findings from this study, there are two situations where it seems appropriate to consider connecting the video system. Firstly, the respondents expressed that the live video system would be beneficial for incidents that are *not obvious* in the initial data collection stage and that requires increased SA for the dispatchers. This relates to the findings presented in Section 5.3 stating that live video can be used to evaluate the degree of different situational elements and to get an overview of the context and adapt measures and advice according to what the dispatchers see. Examples of such situations can be in the case of language problems, in situations where the dispatcher is unsure whether assistance is required, and/or whether the dispatcher should reroute the caller to other agencies. In such conditions, it would further be beneficial to define some specific scenarios where the video system is incorporated in the procedures, for example, in the section for unresolved issues (Nakos, 2018, Nr. 07), smaller bleedings/cuts, and smoke development. Secondly, visual contact with the emergency site seems beneficial during extreme events included in the triple alert routine, when the information is ambiguous and misleading or the bystander is unable to describe the situation. Examples of such events include avalanches, forest fires, and flooding. The nine scenarios included in this procedure are dependent on collaboration and shared SA between the CCCs. All scenarios in the triple alert routine generate heterogeneous information needs among the organizations involved, and by having visual contact with the emergency site the different dispatchers can see the important elements instead of relying solely on verbal information and thus save valuable time. However, for use of the system to be optimal, an important factor is the further integration with the existing systems. The video system must not constitute an additional operation in the dispatchers` workspace as is currently the case.

An important consideration for this topic is that a high load of incoming information can have the same effect as noise (distraction, stress, and error) when making a judgment (Klapp, 1986). An important mark

here is to identify the tipping point for when the video support is beneficial, and when it causes information overload. A multitude of information sources and formats have been proven to generate information overload (Van de Walle et al., 2013), which again results in difficulties for the dispatcher to meet the information needs of the specific situation (Gralla et al., 2015).

7 Conclusion

Since effective emergency management requires the dispatchers to have a continuously updated SA, the emergency management domain should be receptive to technological advancements. The presented study was designed to investigate the multi-agency perspectives on adopting a live video system as a data collection tool in CCCs, using NPT as the theoretical lens. This approach expands our understanding of how to facilitate a technology intervention into the organizational everyday routine, to become normalized in complex workflows such as in the CCCs. Application of the NPT to the emergency management domain can enable a deeper understanding of the normalization process across agencies by focusing on the four dimensions of coherence, cognitive participation, collective action, and reflexive monitoring. However, the original NPT does not include "context" as a core construct which is an essential component when investigating different organizations. In this paper, we have presented an analysis of empirical data based on the four NPT dimensions and added "context" as a fifth construct. The results provided an understanding beyond the impact and effect of using live video in CCCs, namely the process of integrating such novel data collection tools into the complex workflow of the CCCs.

The study has shown that as long as the novel system is not fully integrated into the existing information systems and procedures, it is regarded only as an additional feature that can be used if the situation is not clear and the time allows it. However, the results also document that the system has a place in the CCCs provided it is well incorporated into the routines. We used the NPT for mapping important elements that promote or inhibit the use of live video. The results show that the time pressure and complexity of the dispatchers` tasks affect when the video system is used. Hence, the sense-making process regarding the shared understanding of the expected benefits (i.e. the NPT coherence construct) is not optimal, which leads to low cognitive participation and low collective action. On the other hand, our informants described video streaming to be useful for diffuse inquiries; then the coherence was high and likewise the cognitive participation and cognitive action.

Limitations to this study include the limited number of informants, and the focus on early stage of video system adoption and use. The NPT was used as an analytical framework for investigating how the dispatchers cope with the system in their everyday workflow, within a limited number of CCCs involved, however, they are considered to be representative for Norwegian CCCs. Despite these limitations, the study contributes new insight on an important issue in emergency management, namely how live video can be used by dispatchers for collecting data from the incident scene, and how this can be integrated into the existing workflows in a CCC.

A natural progression of this work will be to investigate further the information overload perspective and how a new source of information, such as the live video system, affects the dispatchers in the CCCs. A focus here could be on identifying the tipping points where the information becomes unmanageable and excessive, rather than supporting situational awareness and decision making. The results also suggest a need for comprehensive mapping of different scenarios where the live video conference should or should not be used. This should then be incorporated as a part of the CCCs` procedures.

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