Received: 27 April 2020 | Revised: 2 July 2021 | Accepted: 7 July 2021
DOI: 10.1111/1468-5973.12373

ORIGINAL ARTICLE

WILEY

Connecting resilience concepts to operational behaviour: A disaster exercise case study

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Funding information
H2020 Security, Grant/Award Number: 653289; Samverkansplattform H2020 Secure Societies

Abstract

Contemporary crisis management studies often make use of the concept of resilience. However, resilience as a term has a wide variety of meanings and has been criticized as lacking operationalization and empirical validation. The current study aimed to link resilience concepts to observable behaviour within a disaster medicine management system. Resilience concepts, captured in so-called capability cards and further operationalized into six resilience prerequisites, were used in the study. An experienced crisis management team participated in a large-scale crisis management exercise and behaviours were captured through observations, video and audio recordings. Using a markers and strategies analytical framework, two blinded raters classified observable behaviours that exemplified resilient practice. The analysis showed a high degree of agreement (79%) between the combined operationalized capability cards and resilience prerequisites and the empirical classification of behaviours. The current study shows an empirical link from resilience concepts to observable behaviours during an exercise. Observed episodic narratives exemplify empirically connected specific strategies to specific resilience markers. These results demonstrate a method with observed narratives for analyzing resilience in crisis management teams using a markers and strategies approach. Future studies can use the results to create structured observation protocols to evaluate resilient behaviours in crisis management teams.

KEYWORDS
command and control, crisis management, modelling, resilience

1 | INTRODUCTION

First responders and crisis management agencies are trained to face a wide range of incidents and have in modern society developed into highly technological and complex networks of actors. However, the accidents and disasters they face have also evolved and are likely to involve multiple systems, actors, and technologies. Thus, first responders and crisis management agencies must understand an increased complexity and have the ability to adapt and coordinate crisis management accordingly. This is often termed resilience.

Resilience is a commonly used concept in disaster management research (e.g., Birkland & Waterman, 2009; Boin et al., 2010;

Lundberg & Johansson, 2015; Soden et al., 2015; Trnka & Johansson, 2011). Resilience for crisis management agencies has gained attention in light of the increased frequency and impact of disasters, including natural disasters, pandemics, and terrorism (Cutter et al., 2010; Zhong et al., 2014). However, systematic literature reviews of the resilience concept have shown that it is remarkably fluid in its definition (Bergström et al., 2015; Son, Sasangohar, Neville, et al., 2020b), with one review of 440 articles finding over 300 different definitions of the term *resilience* (Woltjer et al., 2015). It is thus still unclear what, precisely, resilience is and how it can be trained, measured, or assessed in crisis management systems such as, for instance, emergency healthcare systems (Jeppesen & Wiig, 2020; Son et al., 2019; Wiig et al., 2020). For the purpose of the current study, we define resilience as "the ability to resist, absorb, accommodate to and recover from the effects of disturbances and changes in a timely and efficient manner, including through adaptation and restoration of basic structures and functions" (Woltjer et al., 2015).

According to Righi et al. (2015), a majority of the published articles within the resilience literature have focused on developing theories of resilience. To exemplify some of this theoretical work, Woods (2015) groups resilience according to four different basic concepts: (1) resilience as rebound from trauma and return to equilibrium; (2) resilience as a synonym for robustness; (3) resilience as the opposite of brittleness, that is, as graceful extensibility when surprise challenges boundaries; and (4) resilience as network architectures that can sustain the ability to adapt to future. Hollnagel et al. (2015) describe resilience as comprised of four interrelated and interdependent functions, namely responding, monitoring, anticipating, and learning. Lundberg and Johansson (2015) propose a systemic resilience model, termed SyRes that encompasses six functions, in addition to several functional dependencies and event-based constraints, in a cyclical and dynamic model.

As a result of the many different definitions and theories, resilience has been criticized as not being a useful concept in disaster risk reduction (e.g., Manyena, 2006; Son, Sasangohar, Neville, et al., 2020b). One particular point of criticism is the lack of useful quantification and operational methods (Sheridan, 2008). There are in fact methods for assessing resilience, but there is need for tested and validated methods (see e.g., Cutter et al., 2010; Somers, 2009; Son, Sasangohar, Neville, et al., 2020a). A review of current disaster resilience metrics showed that only 10.3% of suggested metrics have been subject to empirical validation (Cai et al., 2018).

Furthermore, Wiig et al. (2020) performed a recent overview of resilience in healthcare and proposed four core research questions that should direct future resilience research. One of them is "resilience of what?" That is, what components, individuals, or resources within a system support or create resilience? This research question again shows the need for empirically grounded methods to connect resilience concepts to observable behaviours in the systems of interest. Wiig et al. emphasize this point by concluding that further rigorous and empirical work on resilience is needed to develop an "empirically-grounded and theoretically-informed approach to resilience in healthcare" (p. 8). Accordingly, Son, Sasangohar, Peres, et al. (2020d) have studied Incident Management Teams (IMT) active during Hurricane Harvey, and argue for more empirical research performed on a meso-level (rather than macro or micro), on IMT resilient behaviour associated with resilience theory. A closely related concept is hospital resilience, which also needs to be defined in terms of how to best measure it (Cristian, 2018; Son et al., 2019; Zhong et al., 2014).

The purpose of the current study was to link operationalized resilience concepts to observable behaviour within a disaster medicine management system. Preceding work (Branlat et al., 2017; Hermelin et al., 2020; Herrera et al., 2019; Woltjer et al., 2018) developed and operationalized theoretical resilience concepts into concrete guidelines for resilience practice. However, these new guidelines, although based on published theoretical and empirical studies, needed to be empirically validated. The current study sought to use a method developed by Furniss et al. (2011) to study the links between observed behaviours during a large-scale disaster management exercise and these specific operationalized resilience concepts.

1.1 | Operationalization of resilience

In an effort to produce practical guidelines applicable to crisis management, Branlat et al. (2017) describe ten so-called *resilience capability cards*. These cards were developed based on a thorough literature review of current resilience research (see Woltjer et al., 2015). Each capability card describes a resilience concept and related capabilities, as well as proposed interventions to develop and enhance specific resilience management capabilities at a conceptual level. The guidelines were developed to be applicable to critical infrastructures in general but focused on air traffic management and healthcare in particular (Herrera et al., 2019).

Hermelin et al. (2020) describe an effort to operationalize seven of these capability cards into concrete and domain-specific guidelines, called resilience prerequisites, for healthcare crisis management specifically. The six resilience prerequisites were formulated by Hermelin et al. (2020) as follows:

- P1 *Managing goal conflicts/trade-offs within and between actors* concerns how to handle internal and external conflicts of goals, that is caused by actors' different goals and prioritizations. The goal conflicts can be explored by questioning how to identify, avoid and manage goal conflicts and prioritizations.
- P2 *Revealing vulnerabilities* represent the need of identifying and managing vulnerabilities during a response. This could be done by considering what vulnerabilities and capabilities there are in the organization, and how could these affect the response.
- P3 *Understanding crucial assumptions* reflect the need for assessment and managing of explicit and implicit assumptions during crisis management.
- P4 *Being aware of constraints* reflects that managing a crisis often involves an act according to certain constraints

regarding, for example, resources, competence and mandate. One consideration is how to extend the capabilities and overcome constraints.

P5 *Having systemic and capability understanding* stands for the need of understanding that several different actors have different capabilities interconnected through a network of relationships and dependencies.

P6 *Using success factors* reflects the need of identifying and applying experiences that have been successful during previous events (Hermelin et al., 2020).

Hermelin et al. (2020) show how each of these resilience prerequisites builds on resilience concepts from multiple capability cards. Hermelin et al. summarize these links in a table format, recreated below as Table 1. The bullets indicate which capability cards are linked to each resilience prerequisite. That is, the concrete, domain-specific guidelines that are the prerequisites were each based on one or more of the more generic resilience concepts from the capability cards described by Branlat et al. (2017). These prerequisites were also aligned with existing, specific domain terms to phrase resilience in a language that could readily be understood by practitioners.

1.2 | Case study exercise

The case used for the empirical validation in the current study was a large-scale crisis management command postexercise for a medical command and control team within the public health organization Region Östergötland. The exercise was designed, planned and executed by an international team of researchers and subject matter experts with backgrounds in disaster medicine, resilience, human factors and naval search and rescue. The design was executed as a high-fidelity functional exercise where the command and control team acted in real-time for a total of five hours in their ordinary operations centre environment and with access to the normal information and communication setup used to manage real incidents in harmony with Team Emergency Operations Simulation (TEOS) (Son, Sasangohar, Peres, et al., 2020c). In total, about 70 people participated in the exercise, filling different roles such as coast guard point of contact, ambulance dispatch, local incident commanders, as well as various logistical and exercise technical functions. The maritime incident site and resources were visualized with the EmergoTrain System (Berggren et al., 2018) and NetScene (Forsgren et al., 2011). The implementation of decisions taken by the command and control team were carried out by 15 different response cells both at the blunt end as well as the sharp end (e.g., Joint Rescue Co-ordination Centre, prehospital command and control team, hospitals), each operated by subject-matter experts. The objective of the exercise was to give the participants in the command and control team the possibility to apply the six resilience prerequisites during crisis response and establish an actual experience of being in a resilience-demanding situation (Field et al., 2011; Hermelin et al., 2020). Hermelin et al. (2020) also provide a more detailed description of the planning and execution of this exercise.

The scenario presented to the medical command and control team was that there had been a collision between two ships outside the region's mainland on the east coast of Sweden at 08.58 in the morning. The ship involved in the accident was a foreign cruise ship, M/S SPARROW and a medium-sized tanker, ASTRA. The cruise ship had approximately 1 700 passengers and a crew of approximately 400. As a result of the collision, a fire has started that the crew managed to extinguish. The medical command and control team was alerted of the accident at 09.00. The medical command and control team convened at the regional command centre, as they would in a real major incident. Communication with first responder agencies on land and sea were established according to normal routines over Tetra Radio Network and cell phones. Initial reports to the team estimated 200–300 injured of whom 100 required urgent professional medical attention. Burn- and smoke inhalation injuries as well as more extensive blunt and sharp force trauma constituted the main portion of the most seriously injured.

As the incident unfolded, the command and control team were informed that SPARROW set sail towards a port of refuge in a neighbouring region. During the scenario evacuation procedures towards different ports and helicopter landing areas had to be negotiated with the Maritime Incident Commander and Joint Rescue Co-ordination Centre. The scenario in the exercise lasted for five hours and demanded a high level of command, coordination, and negotiation with multiple actors and experts to coordinate casualty and medical transports. The limited access to the incident site on the ship and the difficulties to obtain a clear situational awareness of the accident contributed to the challenges in the scenario.

2 | METHOD

2.1 | Participants

The study sample of interest was the medical command and control team managing the disaster in the exercise described previously. The team consisted of 11 members assuming roles such as the medical incident commander, designated duty officer, and chief of staff. All team members had extensive training and experience in medical command and control work, including experience of working with each other in different constellations.

The team had in the months leading up to the exercise participated in a series of workshops and interventions to increase their knowledge and skill regarding resilient operations. These educational interventions, including the Capability Cards and the six resilience prerequisites, are described in detail by Save et al. (2018) and Hermelin et al. (2020).

2.2 | Collected data material

The exercise was recorded using body-mounted GoPro cameras, stationary cameras, radio and phone call recordings, and field

TABLE 1 Overview of the relationship between prerequisites (horizontally) and capability cards (vertically) as described by Hermelin et al. (2020)

	Resilience prerequisites					
Capability cards	**Managing goal conflicts/trade-offs P1**	**Revealing vulnerabilities P2**	**Understanding crucial assumptions P3**	**Being aware of constraints P4**	**Having systemic and capability understanding P5**	**Using success factors P6**
Sharing information on roles and responsibilities among different organizations	●				●	
Promoting common ground for cross-organizational collaboration in crisis management			●		●	
Establishing networks for promoting interorganizational collaboration in the management of crisis					●	
Enhancing the capacity to adapt to both expected and unexpected events			●	●	●	●
Establishing condition for adapting plans and procedures during crisis and other events that challenges normal plans and procedures		●	●	●	●	●
Noticing brittleness	●	●	●	●	●	●
Identify sources of resilience, learning from what goes well	●	●		●	●	

notes from four trained observers. The analysis was primarily conducted on the video and audio recordings that showed the work of the regional medical command and control team. Of the 11 team members, two were equipped with body-worn cameras. Two stationary cameras, including a 360-degree camera, captured the activity in the control room. Parts of this material, in particular the reoccurring team meetings, were transcribed and used in the current analysis.

2.3 | Analysis

The analysis was based on the framework for analyzing resilience described in Furniss et al. (2011). Their framework conceptualizes resilience on three different levels: *markers*, *strategy* and *observation*. *Markers* are the highest level of theoretical abstraction and are generalizable across domains. The strategy level has moderate generalizability and represents general strategies implemented in a particular domain. The observation level is where resilient behaviour actually happens, and the generalizability is low. That is, the observed behaviours are likely unique to a particular domain or even within a particular event within that domain, but the quantity is high. Within this framework, the term *strategies* is used for more detailed accounts of markers and *observations* are concrete and observable behaviours that exemplify a strategy in a particular domain and point in time. The analysis in the current study used the collected data material from the exercise to find specific behaviours, that is, *observations*, that showed the previously described resilience prerequisites, that is, *strategies*, being used by the command and control team to achieve resilient management of the incident in alignment with the abstract resilience principles described in the capability cards, that is, *markers*.

The first step in the analysis was conducted by two independent analysts using directed content analysis with deductive application. These analysts were novices to the domain but had previous experience in qualitative research methods. The analysts reviewed the material for observations that could be connected to the Capability Cards and the six resilience prerequisites. The analysts were blinded to the purpose of the study.

The analysts identified observations independently in the material and classified them as exemplifying one or more specific prerequisites (i.e., strategy) and capability cards (i.e., marker). The second step in the analysis was a separate subject-matter expert review. In this step, a third analyst with extensive experience and training in medical command and control work screened the observations in terms of relevance and duplications. The analyst verified that the observations were reasonable and also selected a smaller set of observations that were transcribed to episodic narratives that exemplifies the strategy-marker connection. Finally, the resulting set of observations was summarized across the strategies and markers to create a map of which strategy-markers combinations were frequently observed together. As the resilience prerequisites were each based on different combinations of content from the capability cards, the hypothesis was that these combinations would result in more observable behaviours than other combinations.

2.4 | Ethical considerations

All exercise participants gave their informed consent to be observed and recorded during the exercise. The video and voice recordings were collected by Region Östergötland and made available to this current study.

3 | RESULTS

3.1 | Quantitative summary

Table 2 summarizes all 121 observations made by the observers. It was expected that more observations would be made for capability card and prerequisite pairings that followed the hypothesized a priori connections that are visualized with the bullets in the table. A zero is used to indicate that no observations were made for a hypothesized a priori coupling, for example, the marker “Establishing condition for adapting plans and procedures during a crisis and other events that challenges normal plans and procedures” to strategy P2. Numbers with no bullets indicate a connection made in the observations that had not been specified a priori, for example, marker “Establishing networks” to strategies P3 and P4.

Overall, some marker-strategy combinations occurred frequently. For example, there were 18 observations where the strategy “understand crucial assumptions” (P3) was used for the marker “Enhancing the capacity to adapt to both expected and unexpected events”, and 12 observations where the strategy of “having systemic and capability understanding” (P5) was used to “Identify sources of resilience: learning from what goes well”. Some strategies, such as Promoting common ground for cross-organizational collaboration in the management of crisis and Establishing networks for promoting inter-organizational collaboration in the management of the crisis, had few observations in the data material, and for some strategy-marker combinations, there were no specific observable behaviours.

Of the total 121 observations made by the analysts, 95 (79%) were in line with the a priori hypothesized couplings. The remaining 26 observations connected markers to strategies in combinations that had not been hypothesized a priori. This result indicates that the strategies were in general employed in the intended manner according to the design of markers and strategies.

3.2 | Qualitative analysis results

Five of the observations were selected and further developed into episodic narratives, similar to those used by Furniss et al. (2011). These exemplify the type of behaviour and decisions that

TABLE 2 Summary of observed marker-strategy combination

Capability cards	Resilience prerequisites					
	Managing goal conflicts/trade-offs P1	Revealing vulnerabilities P2	Understanding crucial assumptions P3	Being aware of constraints P4	Having systemic and capability understanding P5	Using success factors P6
Sharing information on roles and responsibilities among different organizations.	1●	1		1	9●	3
Promoting common ground for cross-organizational collaboration in crisis management.			1●		1●	
Establishing networks for promoting interorganizational collaboration in the management of crisis.			1	2	6●	1
Enhancing the capacity to adapt to both expected and unexpected events.	3	3	18●	7●	3●	3●
Establishing condition for adapting plans and procedures during crisis and other events that challenges normal plans and procedures	1	0●	0●	5●	2●	1●
Noticing brittleness	4●	2●	1●	4●	2●	2●
Identify sources of resilience, learning from what goes well	1●	3●	1	7●	12●	9

were captured by the observations. Each observation was classified as using a specific strategy connected to a specific resilience marker, and the episodic narratives below show examples of these connections.

3.2.1 | Example observation of the strategy P3 "Understanding crucial assumptions" used for the marker "Enhancing the capacity to adapt to both expected and unexpected events"

The regional medical command and control team receives notification that the cruise ship SPARROW will change its course and go for the port of Oxelösund in Sörmland county. This changes the previous assumption that the ship would dock in Norrköping in Östergötland. The deputy regional medical incident commander informs the command team that the ambulance incident commander has been asked not to send patients to hospitals in Sörmland as their hospital capacity may be needed for patients who are still on board the ship when it docks in Oxelösund.

This episode illustrates how the team understands how different assumptions on where the ship will dock will challenge their current strategies and resource allocation. The team makes adaptations to their current plans and makes an effort to distribute patients to hospitals further from the region that is expected to receive a surge of patients from the ship. By understanding when the assumptions are realized or negated, they also understand which associated prior downstream assumptions that are now relevant and can act and adapt relative to the event.

3.2.2 | Example observation of the strategy P5 "Having systematic and capability understanding" used for the marker "Identifying sources of resilience, learning from what goes well"

At one point during the exercise, the regional medical incident commander says to the medical transport officer that the newly available transport helicopters are allocated to the hospital in Linköping. The regional medical incident commander makes the argument that they could make more efficient use of the helicopters by allocating them to counties further away from the accident site, as they can provide faster transportation for patients to hospitals in those counties than ambulances. Ambulances can instead be used to transport patients to hospitals in a closer vicinity.

This observation shows that the regional medical incident commander and the medical transport officer have a thorough understanding of the emergency response system. Through this understanding, they can identify how a type of resource, the helicopters, can be put to best use. Allocating helicopters to long-distance transportations allows additional care facilities to be used and maximizes the overall transportation time savings. This simple redistribution of resources ensures that each transportation unit is used to its fullest potential.

3.2.3 | Example observation of the strategy P6 "Using success factors" used for the marker "Identify sources of resilience, learning from what goes well"

At one point, the command and control team members discuss the distribution of ambulances. Referring to previous experiences they decide on using a forward rendezvous point, from which the ambulances can later be distributed to specific casualty clearing points. During this discussion, the chief of staff points to a map on a large screen to illustrate different options.

This observation shows the team using past experiences of successful strategies to identify the use of rendezvous points as a success factor and incorporating this in their current decision making. A rendezvous point allows the deployment of resources closer to the accident, which enables a faster response when they are needed. This is connected to the marker "Identifying sources of resilience" by increasing the response capabilities of the system through redistribution of existing resources.

3.2.4 | Example observation of strategy P5 "Having systemic and capability understanding" used for the marker "Sharing information on roles and responsibilities among different organizations"

During the operation, helicopters with medical staff were sent to the ship to evacuate casualties. The regional medical command team realized that they could use this staff to improve the on-board care and triage by re-assigning the medical helicopter staff to stay on the ship and reinforce the small healthcare staff that was present on the ship at the time of the accident.

This observation exemplifies how the team has a systemic and capability understanding of the situation on the ship and that the onboard medical staff is ill-equipped to manage a mass-casualty situation. By placing a resource from their own organization, in the form of medical helicopter staff which they know have specialized training, on the ship they ensure that an actor with a deeper understanding of the current goals and responsibilities is in charge of an important system function, namely emergency triage and transportation decisions.

3.2.5 | Example observation of the strategy P6 "Revealing vulnerabilities" used for the marker "Sharing information on roles and responsibilities among different organizations"

During a video conference with the Joint Rescue Co-ordination Center (JRCC), the chief of staff and the deputy regional medical incident commander point out the importance of having a direct line of communication with the management at JRCC, and the consequences of not including regional medical command and control early in the decision making. The regional medical command and control explain how the collaboration between the two must work, thereby highlighting the roles and responsibilities of each organization.

The purpose of the added context and explanation for the request is twofold. First, it reduces misunderstandings and misconceptions about the roles and responsibilities of the organizations involved. Second, it educates JRCC on the operating methods and requirements of the regional medical command and control team.

4 | DISCUSSION

The aim of the current study was to link operationalized resilience concepts, captured in so-called Capability Cards and resilience prerequisites, to observable behaviours. This was done through a top-down approach connecting markers to strategies to observable behaviours. The main finding of this study was that an alignment was found based on the a priori hypothesized associations between markers and strategies and the empirical observations. Out of the 121 observations, 79% aligned with the hypothesized connections.

Observations of couplings that were novel are generally few (three or less), with one notable exception. The strategy P6 *Using success factors* was observed to be used nine times associated with the marker “Identifying sources of resilience, learning from what goes well”. This actual use of the strategy indicates that there is a connection between this marker and strategy that was previously overlooked.

There were 26 observations that were not associated with the a priori assumed model. The observations that associated Capability Cards and the six resilience prerequisites in an unexpected manner could be interpreted as associations that were not accounted for in the design. These observations should be evaluated in the continuous validation of the Capability Cards and the six resilience prerequisites. It could also reflect observations that were misinterpreted when associating them to Capability Cards and or the six resilience prerequisites. In this case, this would reflect the need of developing validated observation protocols with clear instructions to minimize the risk of observer bias or the need for prior training. Another interpretation of the lack of observations for some hypothesized couplings is that observable behaviours of such marker-to-strategy combinations are infrequent during medical command and control work. This might stem from a weak connection between the marker and the strategy, or that employing such combinations is performed during a different phase of the response work, for example, in the preparation phase. The observations were all made on work during the response phase.

In addition, the lack of observations for some expected connections suggests that some relations between Capability Cards and the six resilience prerequisites may be less important. One example of a lack of expected associations was “Promoting common ground for cross-organizational collaboration in the management of crisis” associations with P1 *Managing goal conflicts/trade-offs within and between actors*, P2 *Revealing vulnerabilities*, P4 *Being aware of constraints and* P6 *Using success factors*. The lack of observations does not necessarily rule out resilience prerequisites, as the observations were based on a single exercise with a certain scenario. Another explanation is that the expected associations are hard to find in an exercise that focuses on the operative management of a crisis, the *during* face, and that the major contribution of “Promoting common ground for cross-organizational collaboration in the management of crisis” would be in the *before* phase of a crisis. Both “Promoting common ground for cross-organizational collaboration in the management of crisis” and “Establishing networks for promoting interorganizational collaboration in the management of crisis” would probably be developed during interactions among actors before a major event as there is no time to get acquainted or exchange contact information during a crisis. Hence, during the exercise, these aspects were already established and would therefore not be observed.

There are certainly limitations that need to be accounted for when making conclusions based on these results. Even though the empirical data was rich and collected in a realistic simulation, the use of a single exercise limits the generalizability and increase the risk of selection bias. The analysts classifying the behaviours were therefore blinded to the study purpose to minimize bias. There is also always the risk that the behaviour in the simulated event does not completely represent the behaviour in an actual event. However, the studied medical command and control team are both experienced in real operative work and regularly participate in simulation exercises. The exercise management staff was also subject matter experts that designed both the scenario and the simulated environment including the actors with whom the participant interacted.

The study participants were trained in using the six resilience prerequisites but the current study does not distinguish to what extent that training affected their behaviour. Potentially, the medical command and control team conducted “business as usual”. That does not necessarily affect the interpretation or the study results as the goal was to observe and trace behavioural observations to resilience concepts. The degree to which the training affected the participants' behaviour is independent of this objective.

5 | CONCLUSION

The current study is using a top-down approach mapping expected associations between two different levels of contextualization and operationalization of resilience concepts to observed behaviours in the crisis management team. The study results indicate that this procedure can be used to identify the behaviour that allows a system to be resilient. In addition, the quantification of observed behaviours together with the qualitative description of episodic narratives contributes to the empirical knowledge based on observations of behaviours, strategies and markers representing resilience. The next step, based on the current results, could be to conduct interviews and field observations in exercises to further develop a set of observable indicators of resilience. The successful development of such an observation protocol, and subsequent integration into crisis management training, would contribute to a more empirically grounded and useful quantification of operational resilience.

ACKNOWLEDGEMENTS

We wish to thank all participants from different organizations that worked with exercise management, observations, and as actors. Significant contributions to the command-postexercise and its visitors' program were made available through the Swedish Cooperation Platform (Samverkansplattform) H2020 Secure Societies, funded by the Swedish Civil Contingencies Agency (MSB) and operated by FOI. Oscar Bjurling and Linnea Bergsten are gratefully acknowledged for transcription and coding of observations from the exercise. Kristofer Bengtsson and Mirko Thorstensson at FOI, Sweden are acknowledged for review and comments on the article. Dr. Luca Save and Dr. Daniele Ruscio of Deep Blue, Italy, are acknowledged for their leadership and guidance of the work package that this study was part of. All DARWIN Consortium members (SINTEF; Istituto Superiore di Sanità; ENAV; Carr Communications, Ben Gurion University, Braunschweig Technical University, FOI, and KMC) are acknowledged for useful interactions as part of this and related DARWIN work packages. The research leading to these results received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 653289. Opinions expressed in this publication reflect only the authors' views and the Agency is not responsible for any use that may be made of the information it contains.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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How to cite this article: Pettersson, J., Jonson, C.-O., Berggren, P., Hermelin, J., Trnka, J., Woltjer, R., & Prytz, E. (2021). Connecting resilience concepts to operational behaviour: A disaster exercise case study. *Journal of Contingencies and Crisis Management*, 1–10. https://doi.org/10.1111/1468-5973.12373