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BEYOND CRISIS RESPONSE: LEVERAGING SOCIOTECH-NICAL TRANSFORMABILITY

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Research paper

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Abstract

We investigate the organizational capacities required to leverage digital infrastructures both (1) in response to crisis and external threats, and (2) in realizing the transformative potential associated with the digital infrastructures. Thus, our research question is: What is required for organizations to be able to transform in the face of disruptions and breakdowns? We report from an empirical study of a digital infrastructure innovation process in the context of the COVID-19 pandemic, which involved extensions and novel development of both the technology and the former service model. While the literature on organizational resilience offers us a conceptual framework to identify organizational capabilities, we lean on literature that foregrounds transformability as a crucial aspect of resilience. We discuss organizational capacities which are considered vital in realizing the potential for transformative crisis learning in sociotechnical systems that builds adaptive capacity and influences the enactment of future organisational routines.

Keywords: organizational resilience, transformability, COVID-19 pandemic, digital infrastructure.

1 Introduction

In these times we experience that the foundations we believed were stable and dependable can change abruptly. For instance, when pandemics, disruptive weather events, or socio-political unrest upset routine operations, the inherent fragility of the technological and societal infrastructures we took for granted is revealed (Paton & Buergelt, 2019). Facing future uncertainties, the ability of humans to improvise, adapt and learn will be a crucial part of future skill sets (see Durugbo et al., 2021; Toft et al., 2005). We need "to acquire dynamic capabilities to adapt and learn in the face of rapidly changing environments" (OECD, 2021; Lampel et al., 2009). These issues represent the ulterior motivation for our focus on the capabilities required to meet such an uncertain future.

Future-oriented methods have already been introduced in various design- and policy-oriented discourses: Foresight studies may employ horizon scanning, forecasting, or scenario planning in attempts to include the possible futures into decision making – either through extending the horizons for thinking into longer-term timelines or through deliberate envisioning of alternative futures. Future studies encompass a host of various theories of change at micro-, meso-, and macro-levels (Minkkinen, 2020). UNESCO points to the capability of Future Literacy as "an essential competency for the 21st century", "a universally accessible skill that builds on the innate human capacity to imagine the future" (UNESCO, n.d.), where its value lies in countering the poverty of the imagination. Within technology-oriented design discourses, we can find applications of anticipatory design (Clèries & Morrison, 2020; Morrison et al., 2020), design fiction, speculative design (Auger, 2013), and transformative service design (Alkire et al., 2020). Within the information Systems field, there is acknowledgement of how unstable environments increasingly yield fast-changing technologies and scholars posit that a mindset shift to embrace the 'unstable' is needed (Fischer & Baskerville, 2022). There is a dearth of analysis of what such future-

oriented organizational capabilities look like in reality, with limited attention to future oriented study forms, with some exceptions, (Chiasson et al., 2011; Hovorka & Peter, 2021),

It is pertinent for organisations operating in the current climate to develop insight into the capabilities required to meet a future characterized by non-reducible uncertainty, vulnerability, and emergence. Often such capabilities are denoted as *resilience*, a term originally coined to characterize the capacity of socioecological system to recover from a crisis (Holling, 1973; Walker et al., 2004). In the organisational context, resilience is characterised as "the maintenance of positive adjustment under challenging conditions such that the organisation emerges strengthened and more resourceful" (Vogus & Sutcliffe, 2007). Our interest lies in the notion of positive post-crisis outcomes, that strengthen the current entity and future entities. We will build on this organisational resilience literature, which we review in the next section, and specifically target the capacity of transformability.

The research question we address in this paper is: ***What is required for organizations to be able to transform in the face of disruptions and breakdowns?*** More specifically, we examine what it takes to mobilize digital infrastructures in a crisis response situation and which capabilities are required to not only respond but to realize (some of) the transformative potential associated with digital infrastructures. We report from an empirical study of a process where a pre-existing digital infrastructure was repurposed as a crisis response measure. A group of healthcare innovators deployed a digital solution for following up on patients with a confirmed COVID-19 infection at home. Beyond repurposing, this also involved extensions, deepened usage, and novel development of both the technology and the service model. Thus, we argue that this goes beyond just a crisis response to also constitute an innovative expansion of the health services.

In the following section, we review related literature on resilience, while section 3 presents the background for the empirical study and the research approach. Section 4 provides our analysis of the presence and absence of resilience capabilities in the case. The discussion follows in section 5 before we conclude the paper in section 6.

2 Resilience in sociotechnical systems and organizations

2.1 Resilience in socioecological and sociotechnical systems

Following on from Holling's (1973) seminal work on resilience that focused on the 'resistance and stability of ecological systems', the term has migrated to other scientific fields such as socioecology (e.g., Walker et al., 2004), systems theory, and sociotechnical systems research (e.g., Heeks & Ospina, 2019; Rehak et al., 2018). The latter research domains have developed insights into a systems' ability to respond to external stressors where resilience is reflected in a system's preparedness for, absorption, recovery from, and adaptation to a disruptive event. Rehak et al. (2018) draw distinctions the authors deem necessary for the assessment of resilience in sociotechnical systems – highlighting that there are technical (robustness, recoverability) and social/organizational (adaptability) aspects to resilience that must be assessed simultaneously. The authors unpack adaptability to comprise innovation processes, education and development processes, and risk management. However, this dichotomous representation of technical and organizational resilience by Rehak et al. (2018) does not consider the interconnectedness of elements in sociotechnical systems. Similarly, Walker et al. (2004, p.3) define resilience in the context of large disturbances as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks." The authors emphasize that resilience is only one out of three main attributes necessary to explain system dynamics, the other two being adaptability and transformability. While in Holling's (1973) early work the emphasis is placed on a restoration to a known state, later studies in socioecological and sociotechnical studies are oriented towards the continuous retention and carrying forward of necessary lessons learned during a disturbance, i.e., adaptability and transformability (Amir & Kant, 2018; Walker et al., 2004)

In this paper, we are especially interested in transformability, which is required at points when "it may prove necessary to configure an entirely new stability landscape" (ibid., p. 6). The capacity of transformability is defined as "the capacity to create untried beginnings from which to evolve a new way of living when existing ecological, economic, or social structures become untenable" (ibid., p. 6). In focusing on transformability, we follow Amir and Kant (2018) who transpose the discussion from socioecological systems where it emerged (Walker et al., 2004), to sociotechnical systems. They argue that sociotechnical systems tend to have smaller scales than socioecological systems, and that intentional, actor-driven change is more significant in sociotechnical systems. Therefore, the capability of *transformability* will be more significant in these contexts and therefore they argue for an understanding of sociotechnical resilience that foregrounds transformability.

A fundamental aspect of this transformability discussed by Amir and Kant (2018) alludes to sociotechnical change. Sociotechnical change is characterised by systemic adjustment/ updates to routines, processes, and practice (Sarker et al., 2019). Based on the premise that change is central to sociotechnical systems dynamics, we should aim to design not only resilient systems that can "bounce back" but should also consider "how quickly and robustly a sociotechnical system transforms from one state to another" (ibid., p. 11). This is further supported by recent literature in sociotechnical change theory, that asserts the temporary nature of 'stability' in modern sociotechnical systems that are now seen to be characterised by being prolonged states of 'unstable equilibrium'. In such configurations, the surface-structures are continuously unstable while the deep structures maintain stability (Harder Fischer & Baskerville, 2018) . This thinking is consistent with recent studies that highlight the possibility of 'bounce forward' resilience (e.g., Russpatrick et al., 2021) where learning, from either positive or negative experiences, is a prerequisite for system viability and secures future safety. Any learnings are incorporated into future system configurations and arrangements (Lundberg & Johansson, 2015). Extant literature is rich in theoretical conceptualizations highlighting that disruption can create opportunities for learning, adaptability, and transformability through a sociotechnical resilience process (Russpatrick et al., 2021; Sakurai & Chughtai, 2020). If we acknowledge that modern sociotechnical systems are in unstable equilibrium, it is implied that the surface social and technical structures in the systems are fluid, providing possibilities for continuous reconfiguration, i.e., dynamical stabilization seen in transformability. We understand that the future favours sociotechnical system models that promote this dynamic interplay between resilience and change. There is a call for practice-oriented studies that provide an understanding of the nature, and the requirements for transformability to occur in real-world contexts (Amir & Kant, 2018) and to develop sociotechnical change models reflecting a balance between flexibility and stability (Fischer & Baskerville, 2022). In this paper, we wish to examine the nature of transformability in contexts of even smaller scale (sector-level sociotechnical systems) than what Amir and Kant (2018) discussed, such as transportation, electricity supply, etc.

2.2   Resilience in organizations

In organization-focused research, resilience is conceptualized and studied as a meta-capability comprising a combination of organizational capabilities and routines (e.g., in Lengnick-Hall et al., 2011) with the potential to capitalize on a perceived disruption through a positive adjustment (Vogus & Sutcliffe, 2007). We are interested in capabilities at the organizational level, and while there exists a significant research stream on such organizational capabilities, they are, however, usually defined related to resilience during crisis rather than specifically as capacities for transformability. Transformability can be used to introduce positive routines and actions that promote resilience (Kayes & Yoon, 2020). Based on Teece et al.'s (1997) notion of dynamic capabilities, resilient organizations are often seen to possess capabilities that enable them to respond to changing conditions through adapting, integrating, and reconfiguring internal and external resources and competencies (Teece et al., 1997).

Some researchers also incorporate notions related to anticipation. For instance, Stephanie Duchek (2020) identifies three successive resilience stages – anticipation, coping, and adaptation – and assigns important organizational capabilities to each of these stages (Duchek, 2020). She defines "organizational resilience as an organization's ability to anticipate potential threats, to cope effectively with adverse

events, and to adapt to changing conditions." (ibid., p. 220). To **anticipate** potential threats and critical development, she lists three specific capabilities: (1) the ability to observe internal and external developments, (2) the ability to identify critical developments and potential threats, and (3) to prepare for unexpected events. This anticipation yields a resilience potential that is not presently evident or realized, only latent. In the **coping** stage, the capability of (1) accepting, (2) developing solutions, and (3) implementing solutions are key. For this, improvisation in the form of recombination of actions already in the organization's repertoire is crucial, as shown by (Weick & Roberts, 1993). It is worth noting that the ability to develop solutions not only means idea generation, but also coordination, and that actually implementing solutions that have been developed may be challenging. Finally, the **adaptation** stage indicates the ability to learn and/or transform after critical situations have occurred. This ability refers to adjustments following crises and is directed toward organizational advancement long-term learning. Adaptation includes two types of capabilities: (1) reflection and learning and (2) organizational change capabilities. Duchek's model supports the stages of resilience, highlighting how resilience precipitates a crisis, prevents escalation. The adaptation stage sparks the central consideration in this paper of transformability.

2.3 From resilience to transformability

While Duchek's three stages of resilience and the associated organizational capabilities give us a starting point, we wish to focus on transformability rather than generally on resilience, we return to Amir and Kant (2018). They define three core aspects of the organizational and/or institutional reconfiguration associated with transformation - informational relations, sociomaterial structures, and anticipatory practices. Informational relations can strengthen resilience through "designing effective informational networks, implementing cross-scale information couplers, regulating the flow of information, and making information available to the targeted audience proactively during crisis." (ibid., p. 12). Regarding the sociomaterial structures, Amir and Kant ask "how flexible is the sociomaterial structured and is it designed such that it will allow the sociotechnical system to undergo transformation to avert disaster and to metamorphose in the aftermath of disaster? "(ibid, p. 12). Moreover, they remind us that "these structures enable certain practices while curtailing others" and that "a notable aspect of these sociomaterial structures is their interpretive flexibility due to interaction with various groups and subgroups" (ibid, p.13). The ability for technologies to be used in different situations by different user groups "is both supported and limited by the technical constitutions of the artifacts". (ibid., p. 13). Finally, anticipatory practices refer to "the construction of regular activities aimed at anticipating possibilities of what would occur in the future" (ibid., p. 13). This does not only focus on bouncing back to become fully operational again, "but also the possibilities of averting disasters and extending the horizon for safe functioning of the system" (ibid., p.13).
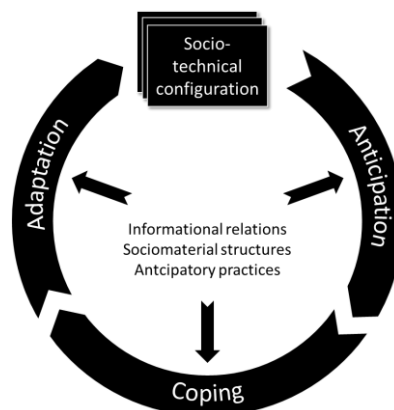

Figure 1. Sociotechnical transformability

The combination of Duchek's (2020) process model of resilience and Amir and Kant's (2018) facets of transformability constitutes our analytic framework of *sociotechnical transformability*. In Figure 1 we

fuse Amir and Kant's three core aspects of transformability and show how they feed into each phase of the resilience process as modelled by Duchek. It is our understanding that the sequence of events is best structured and understood through the Duchek model, however, to acquire in depth understanding of the reconfiguration, underlying processes, routines, and practise, we infuse the concepts of informational relations, sociomaterial structures, and anticipatory practices into the analytic model and apply them in combination. The relevance of this approach is exemplified in the adaptation stage of resilience which anchors processes of reflection and change that transform lessons into sociotechnical configurations and capabilities that influence future organisational routines and build adaptive capacity. This sociotechnical perspective on the resilience process provides deepened insight into the requirements that enable organisations to pivot into transformation in the face of breakdown/ disruption. The following section provides details related to the background for empirical study and our approach.

3 Case background and research approach

3.1 Case: digital home monitoring of patients

The Agder region in the south of Norway has a population of slightly above 300 000 inhabitants, spread over 8 towns and 25 municipal districts. The municipalities are responsible for the primary health and social care services, which are predominantly public. The Hospital of Southern Norway has branches in three of the towns and employs over 7000 staff. Different electronic health record systems are in use: the hospital uses an Electronic Health Record (EHR) system made for the specialist health services, the municipalities used different EHR systems for their nursing homes and home care services (three different products across the region) and the General Practitioners use other systems (four different products). To facilitate interaction in the fragmented ICT landscape, a shared national broadband infrastructure (the Norwegian Health Network) and a messaging standard allow the exchange of structured digital messages between these different systems, such as referrals, lab requests, discharge reports, etc. Sharing of information among multiple health care actors is highly relevant in the care of patients with complex chronic conditions who often suffer from more than one disease because this patient group is frequently in contact with both primary and specialist health services. This is the reason for the region's long-standing efforts (dating back to 2013) to establish an innovative digital infrastructure that can support the ongoing shared care for this patient group. The targeted demographic was older persons with chronic conditions (e.g., diabetes, heart disease, or chronic-obstructive pulmonary disorder).
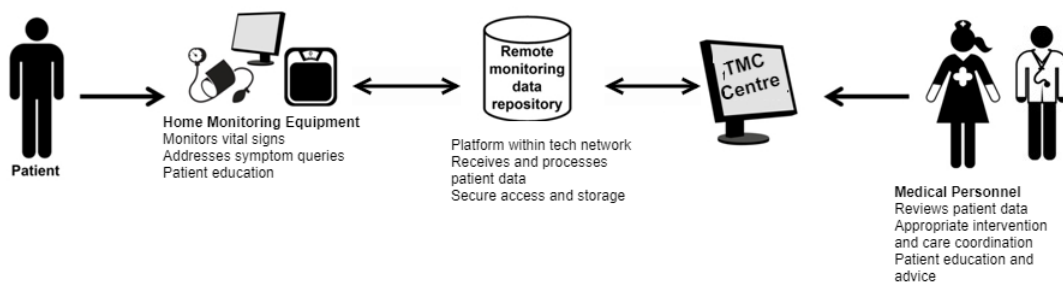

Figure 2. Service concept for patient facing infrastructure

The initial deployment of the solution (as depicted in Figure 1) comprised a combination of technical and organizational infrastructure. A patient-facing frontend was based on tablets with blue-tooth-connected devices, and a health personnel backend that showed data from all patients was installed in a response centre (called a telemedicine central or TMC) which was staffed by health personnel. There were established agreements with hospitals and general practitioners (GPs), who had access to the same

platform and data. At the time of the start of the pandemic, these services were provided in the context of a region-wide project. This pre-existing solution is the focus of our case study.

In the time leading up to the COVID-19 outbreak being officially declared a pandemic by the World Health Organization on March 11, 2020, the regional leadership had mobilized crisis response protocols in the region. Early media reports of unfolding events in other countries (e.g., Italy) created anticipation of similar infection trends locally, which drove efforts for crisis preparation and mitigation. As a direct result of these initial efforts, a decision was made to repurpose the digital infrastructure that was used for patients with chronic diseases. It was updated and deployed already on March 19th, 2020. In Figure 3 we offer a timeline highlighting the key phases in the process during 2020.
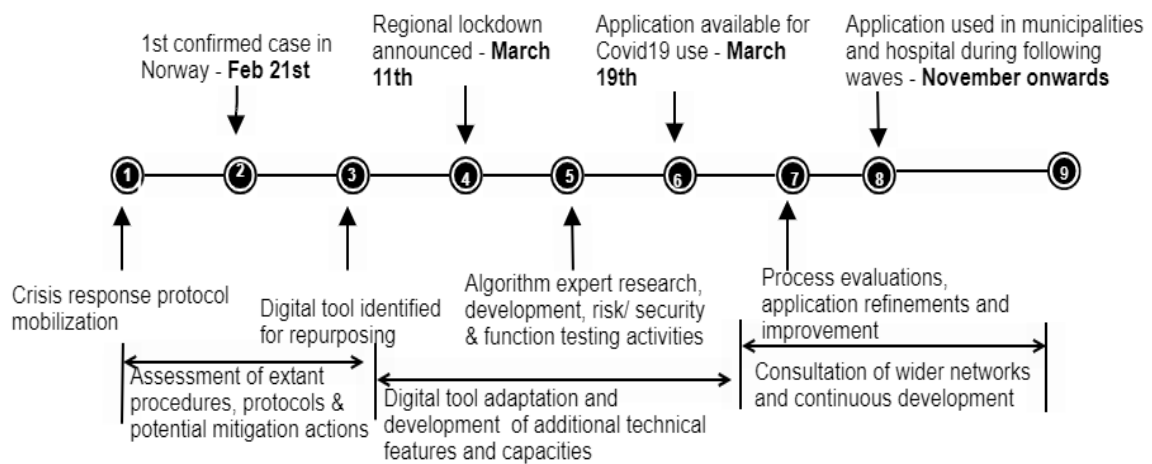

Figure 3. Case chronology

3.2 Research approach and data gathering

We have conducted a qualitative case study with the aim to characterize organizational behaviour during the anticipation, coping, and adaption stages of the pandemic. The case encompasses the involved healthcare actors within the region, centred around the project team behind the patient-facing infrastructure (hereafter called PFI). The PFI project team worked under an overall, regional project organization that comprised all regional municipalities in a formal structure created to support the implementation of digital solutions. In our material, three different healthcare organizations are salient, one large and one small municipality, as well as a hospital. The backdrop for this research is a long-term (~10 yrs.) research collaboration between the University and healthcare actors on establishing a patient-facing infrastructure (PFI) for remote monitoring of patients with chronic diseases. More specifically, since March 2020 there has been ongoing contact with frequent update interviews, and a formal project-based collaboration since July 2020.

The data collection has been based on these frequent update meetings, informal discussions, and formal interviews with involved staff in both the municipal team and the hospital. A series of 16 formal interviews totalling 30 hours in duration, over a 2-year period were conducted and transcribed. Interview subjects included the PFI project team (4 persons), Org-X (the technology vendor; 2 persons), clinical personnel, and crisis managers from the municipalities (3 persons) and the hospital (2 persons) in which the solution was implemented. The interviews were conducted in either Norwegian or English with a blended format of digital (on Zoom) and physical meetings when possible. Analyses of policy documents, guidelines, and reports produced during the project period (2020 - 2021) which describe the solution and the experiences during the development, implementation, and use phases are also included.

÷	Position (number of interviews)	Organization
Inf-1	Head of Digital and Enterprise Services (1)	Org-X
Inf-2	Digital Solution Lead (1)	Org-X
Inf-3	Head of Research & Medical Doctor (2)	Fjord Municipality
Inf-4	PFI Project Program Manager & ex Rescue Medic (2)	PFI project team
Inf-5	eHealth Research Innovation Manager (2)	Fjord Municipality
Inf-6	eHealth Advisor (2)	Yaro Hospital
Inf-7	Nurse (1)	Yaro Hospital
Inf-8	PFI Design Lead & ex Nurse (1)	PFI project team
Inf-9	General Practitioner (1)	PFI Project team
Inf-10	PFI Security Lead (1)	PFI project team
Inf-11	PFI Distribution Lead (2)	PFI Project team

Table 1: Study informant profiles

3.3 Data analysis

Due to our familiarity with the case and contextual dynamics in the region, the emphasis of our research focused on the interrogation of the research data to extract practical consequences. This pragmatic approach in organisational processes facilitates the exploration and understanding of the relations between theoretical knowledge and practical actions in context. (Kelly & Cordeiro, 2020). The study explores the project's progression with a specific focus on the capabilities, and organizational skills required in the adaptation and implementation of the patient-facing infrastructure.

The analysis was theory-driven, conducted in two stages, drawing from the sociotechnical resilience analytic framework described in Figure 1. To guide the coding and thematic analysis, we employ Duchek's (2020) three phases of anticipation, coping, and adaptation to structure the empirical material, and identify the underlying organisational processes, capabilities, and functions. This is detailed in the case insights section of the paper. Thereafter, we identify the role of informational relations, socio-material structures, and anticipatory practices. We searched for salient actions and decisions at each of the stages, then discuss and unpack the required capabilities from a pragmatic stance in the discussion section. The following section details the key insights from the empirical study.

4   Case Insights: resilience as transformability

Our study followed the design and development of functionality and procedures of the patient-facing infrastructure which was coordinated by the regional PFI project team. In addition, different municipalities and the hospital would follow different trajectories in the implementation of the solution, based on different needs, internal structures, and processes. We here present our analysis according to the three stages of anticipation, coping, and adaptation.

4.1   Anticipation: latent resilience

The three specific capabilities that Duchek (2020) associates with anticipation were: the ability to observe internal and external developments, the ability to identify critical developments and potential threats, and the ability to prepare for unexpected events. Here we describe our observations concerning these aspects. These anticipatory capabilities appear to have been reasonably well supported in the organization. *Inf-3* recalled: "*for those of us who have a background in medicine, and epidemiology, the potential of a possible pandemic was obvious quite soon...we had a plan, the pandemic response plan was not that old, it was used as a basis for the risk assessments on the sector*". This risk assessment involved analysis of the level of exposure the region would likely suffer due to COVID-19 infections

and to what extent there were available resources to meet the demands of coping with the crisis. Short-term measures were required to protect crisis management personnel from infection because their good health and availability were critical to the overall outcome of the health service. *Inf-5* recalled: "*We established a crisis organization, and let many persons work from home office… the municipality found resource persons to take part in the work of risk assessments and develop plans to cope with the possible challenges that might come due to infections, especially regarding locking down parts of normal activities*". Responding to the need for social distancing and protecting health personnel by removing them from face-to-face service could lead to unforeseen cascading effects and complications. *Inf-3* recalled: "*other very important things we did was make continuation plans, there was also the dilemma of the consequences of closing - about defining what groups of employees had critical functions. So, it was not clear when the pandemic started.*" The existing pandemic response plan was made for an influenza type of pandemic rather than for a respiratory disease that COVID-19 initially was understood to be, implying the plan had deficits, and needed to be revised.

The anticipated rise in infection was of great concern to the health services, but at the same time, there was little knowledge about the disease and little preparation for specific needs such as personal protective equipment (PPE). Thus, the existing capabilities to observe development and identify threats could leverage the preparations that had been made earlier. However, the preparations were not sufficient to encounter this novel threat. In the words of *inf-6*: "*within the healthcare sector, we were not prepared to cope with this kind of the contagious disease like COVID-19…there was also a lack of the PPE, and that underscored the importance of being able to be in contact with the vulnerable groups and to provide online and digital follow up*". Another concern was related to the projected number of patients, reflected by *inf-4*: "*Thinking how we can help infected patients with COVID-19 to help them stay home as long as they possibly can, without seeking medical attention*". As an outcome of mobilizing the latent resilience capabilities and assessing them, gaps were detected and spurred the mobilization of innovative coping capabilities.

4.2 Coping: innovation as crisis response

The anticipation capabilities had ensured that the coping response was underway well before the region went into lockdown. *Inf-1* and *inf-2*, personnel from Org-X recall: "*the whole organization actually changed focus within weeks to prepare for the worst-case scenario together with the municipalities*". Following Duchek's (2020) model, after accepting and recognizing the crisis, the capability to develop and implement solutions are key aspects of coping capabilities. This requires improvisation or bricolage, and Weick (1993) argues that novel recombination of actions already in the organization's repertoire is crucial. The importance of such recombination of both informational and sociomaterial relations was evident in this case. At a general level, we see such an improvisation in the choice to repurpose the existing digital infrastructure for the novel needs. The existing patient-facing infrastructure (PFI) was in use for the vulnerable group of older patients with chronic conditions, and recruitment was ongoing for a randomized controlled trial addressing the clinical outcomes of this mode of follow-up. *Inf-4* said: "*We were kind of in the middle of the inclusion of other patients into our PFI study. […] a lot of our patients that we want to include in our study are in the risk groups…my thought was that if we could use our technology and our network … also, because we have a telemedicine central. So, I thought we could just […] take this system and scale it*". Although the system had been in use for a while, the digital platform was not ideal for scaling to cater for the projected COVID-19 patient numbers. Also, the functionality of vitals and symptom reporting had not been designed specifically for the COVID-19 symptoms. Thus, several revisions and changes needed to be considered. This required further development and mobilization of resources, both in terms of clinical and technical expertise and resources.

4.2.1 Latent network relations enable emergent response teams

While the digital PFI solution had been used for both patients with diabetes, heart disease, and chronic obstructive pulmonary disease (COPD), none of the screening algorithms in use was appropriate for

COVID-19 patients. The development of a custom patient screening algorithm was thus a key step in developing a solution. For this, an ad hoc team of medical doctors was summoned. This drew on informal networks within the region and included a pulmonary specialist who had participated in developing the COPD algorithm earlier, as well as GPs with experience in digital patient follow-up. Throughout a few days, this team (meeting only virtually) iterated on the pre-existing COPD algorithm, taking away some symptom measures and adding others. All the time the team would consider the emerging knowledge on e.g., symptoms and progression from official sources such as the World Health Organisation, and the National Directorate of Health. This is an example of a coping capacity that depends on "knowledgeable people self-organize into ad hoc networks to provide expert problem solving" (Weick et al. 1999, p. 100). This was not a formalized network, only a latent resource based on personal knowledge and previous collaboration experience. It could be mobilized in this situation and then be dissolved again. Such organizational forms are also described as emergent response groups (Majchrzak et al. 2007).

4.2.2 Flexible and modular technology enables swift innovation

However, defining the clinical algorithm for follow-up was only one initial part of the solution. The pre-existing deployment model was based on a "patient kit" comprising a tablet and select medical biosensors that was physically delivered to the patients' homes. This was not considered to be a scalable model in the face of the existing uncertainties. *Inf-8* shared: "*we didn't know at that moment if we are going to have 10 patients or 10,000 [...] So, we needed to jump from that rigorous system to a more scalable system, so an application with bring your own device – BYOD – but also with two-factor authenticated login.*" The existing digital solution was delivered by a large international vendor of healthcare technology (Org-X), who quickly developed a web interface. Using this interface, patients at home could enter data – i.e., symptoms and measurements, using their own equipment such as thermometers. A couple of weeks later also a downloadable application (app) was available. The patients who were enrolled would get an SMS with a web link and could download the app and start registering their symptoms. Thus, this BYOD model guaranteed dramatically wider accessibility to the service, with an equally dramatic reduction of logistics and device costs associated with offering it.

Expedited user testing was conducted with test subjects recruited informally within the organizations' employee pool, their family, and friends. Any feedback required from this phase was incorporated into the prototype. However, it was considered that the move to a BYOD model required more proper security testing. While the pre-existing system was used by an older adult demographic, this would change with COVID-19 patients, and this might have other security-related implications. Two-factor user authentication was introduced, and further steps were taken. *Inf-10* shared: "*it's completely different stuff when you're on your own device on iOS, Android, and it's also because we were working with older people, so the chance of old Ole trying to hack the system was low. Going public with another prototype was different*". In addition to the security testing conducted by Org-X as a part of system development, a security task force was put together at the regional level. Following the recommendations of the security task force, independent consultants were engaged to conduct two rounds of penetration testing. The flexibility and modularity of the underlying technical platform were crucial for this development to succeed.

4.2.3 Mobilizing pre-existing skills and structures

The follow-up was conducted by the same telemedicine central as the pre-existing follow-up of patients with chronic diseases. The COVID-19 extension was running on the same technical platform as was already in use here, and which the existing staff was already familiar with. Furthermore, the staff was used to remote follow-up of patients, which included making judgments of whether an intervention would be required. The pre-existing service was not intended to respond to emergencies and was operational only in the daytime on weekdays. Including COVID-19 patients represented a different task and novel clinical risks. *Inf-8* recalled: "*Another risk was non-responsive patients, being at home, and the risk of the application not catching deteriorating patients because we see a trend where on day five,*

some patients would have a sudden dip". To counteract the possibility of missing out on deterioration, patient were required to submit measurements twice daily, not once as other patient groups. Also, the monitoring staff would make mandatory calls to patients on day five, to confirm the patients' condition. This could be done via the integrated video and messaging functionality. This was a decision made based on recommendations from clinical personnel to ensure patients received optimal care.

The regional PFI project team had initiated the decision to develop the COVID-19 module together with the technology vendor. However, the choice to implement would be made by the health service provider at the municipal level or at the hospital. *Inf-11* recalled: *"We contacted the municipalities that we already had a collaboration with, to see if they could test it out on patients and some of them did and some of them didn't".* Following the March lockdown, the infection curve flattened, and things somewhat stabilized soon after that as society headed into the summer with very low case numbers. Three of the health care providers we studied made very different choices – the Yaro hospital, the River municipality, and the Fjord municipality, which had all participated in the ongoing PFI project using the pre-existing system for patient follow-up. The hospital decided to use the PFI infrastructure and offer home follow-up to allow the earlier discharge of COVID-19 patients. Due to low infection numbers in the region, the hospital had received a 'manageable' number of patients and decided to continue with the kit-based deployment protocol.

Fjord municipality is a large municipality with a central role in the ongoing PFI project. Employees from Fjord municipality were central resources in the team that developed the solution initially and spend a lot of resources on developing version 2 (which we describe in the next section). Despite this, Fjord municipality decided in September 2020 to not deploy the COVID-19 module. Also, when later waves of infection hit harder than at the start, the inhabitants of the city did not get an offer of home follow-up when they were ill with COVID-19. River municipality is a relatively small municipality that experienced an unexpected outbreak in November 2020 with relatively high numbers of infections in a short period of time. The municipality chose to implement the COVID-19 module and throughout this outbreak wave, 62 patients used the application to log their symptoms. The general practitioners were involved, and based on individual patient needs, made recommendations for the extra provision of e.g., sensors to measure oxygen saturation for specific patients. The service received favourable reviews from both healthcare staff and patients, highlighting the ease of use and effectiveness of the service provision.

4.3   Adaptation – learning and transformation

Duchek's (2020) third stage – adaptation – points to the ability to adapt, adjust and use change for the organization's own purposes in a form of long-term learning. In her model, adaptation includes two types of capabilities: (1) reflection and learning and (2) organizational change capabilities. The long-term results of the changes made in the coping phase depend on the attitude towards the future. Amir and Kant (2018) point to transformability as crucial, consisting of "intentional activities, focusing on the ability of sociotechnical systems to shift from one form to another in the aftermath of shock and disturbance". This is a specific form of learning and change, one that deliberately attempts to change its form. This is a quite vaguely defined, but crucial capability for the future. In this section, we will recount the elements of the case story that points towards the presence or absence of such capability to reconfigure its structure and operations in the light of the future.

4.3.1   Preference for short-term coping strategies

 Despite successful implementations at River municipality and Yaro hospital, the PFI team struggled to get most municipalities to take up their innovative new solution. They were in dialogue with both the cross-municipality regional coordination group and individual municipalities. The team preferred that the system be tested in live environments before the second wave of infections. *Inf-4* recalled: *"it was difficult to get municipalities (decision-makers) to try it out. Because I tried to communicate to the big municipalities that if we could test it and take the steps to further develop, then you can have a more robust system when numbers take off".* One interviewee from Fjord recalled: *"we didn't have the need for it".* The onset of the second wave presented another round of opportunity for the project team to see

the system in live action on COVID-19 patients, but also this was not smooth sailing. *Inf-11* recalled: *"When COVID-19 started to come back for the second wave we tried to contact the municipalities again and it was difficult to get a response. It was – 'We don't know, we want more information, or we don't know the benefits'"*. In the face of extremely high demand for the municipal healthcare service, the pandemic was not perceived as a conducive situation for experimentation, and the municipalities were only using the solution when the novel service model overlapped with the perceived immediate needs. The more long-term perspective, seeing the potential of transformative change afforded by taking up the COVID-19 module, was primarily held by the PFI team.

4.3.2   Innovation in preparation for change

When the Fjord municipality was reluctant to initiate a new service, one of the arguments was that the responsibility for patients who do not already receive municipal, or hospital healthcare services resides with the general practitioners (GPs). The staff at the telemedicine central was the municipal staff that cared for the patients in the PFI project. *Inf-5* from Fjord said: *"the responsibility for patients with COVID-19 belongs to the GPs. So, they would always be the first to follow up patients. So, it was important for us not to go outside the established responsibilities"*. In response to this sentiment, the PFI project team and the vendors initiated another development process and came up with a version of the app that did not require follow-up from the telemedicine central. This version rather had automated screening where the patient would receive feedback according to the same "traffic light model" that the telemedicine central solution used – with a red, yellow, and green light indicating the criticality. If the measurements and responses triggered a red alarm, the patient would then get a message advising him or her to contact healthcare personnel. However, the implementation of this version stalled, as no one was willing to take on the extra costs of setting it up or integrating it to the GPs electronic health record (EHR) systems. The need for separate login details to access patient data was flagged as an 'inconvenience' by the doctors. Another major reason was that the independent GPs were not organized in a way that they could collectively make decisions or take on responsibility for such a solution. When asked whether the work put into the system had made a difference, *inf-4* in reflection shared: *"making that application speeded up the change from kits with tablets to the BYOD format. So, we take the work we did for COVID-19 into making our other patients' lives better, we can jump multiple steps in improvements"*. The learning from this development was thus fed into the work of the PFI team, but the opportunity to gather hands-on experience with using a GP-oriented follow-up solution was missed.

4.3.3   Spreading of the innovative service model

Other actors displayed processes of learning and organizational change that carried through to the actual implementation of novel models into routine service provision. The deployment of digital home follow-up in the Yaro hospital had happened somehow disconnected from the municipal processes. The initial utilization of the PFI solution that allowed for early discharge of COVID-19 patients supported by digital home monitoring was noted by other employees in the hospital. When the adapted PFI solution was presented at the Yaro hospital, managers from other clinical areas saw the usefulness of the solution for their clinical domains. This led to further adaptations of the PFI in areas such as early discharged new-borns in need of extra monitoring and increased self-management of HIV infections for reduced hospitalization. These examples demonstrate how both the flexibility of the technology and the mobilization of the informational network, were crucial in the diffusion and adaptation of the FPI solution. This was supported by the interviewees who stated the importance of communicating ideas and solutions in the early stages of the pandemic.

The diffusion of the FPI was not limited to the Yaro hospital. Through the hospital's participation in international research projects focusing on digital follow-up, the same PFI for COVID-19 patients was adopted in other Scandinavian hospitals. This research participation also stimulated the development of additional models for home hospitals. An example of such a spinoff included the idea of using digital technology in ward visits to maintain social distancing. By equipping an assistant with a wearable camera, clinical personnel could attend the ward visits remotely, e.g., from offices or from home. This idea

was developed at the Yaro hospital and was further tested and implemented in one of the collaborating Scandinavian hospitals. For the diffusion of innovative service models to happen, interviewees stated the importance of communicating ideas and solutions in the early stages of the pandemic.

5 Discussion

Decision-makers and clinical personnel had to find innovative solutions to cope with the pandemic, which implied implementing novel patient care models. The case is an instance of crisis-driven innovation that depended crucially on repurposing the existing patient-facing infrastructure. We are interested in the organisational capacities required for this. As previously mentioned, our approach has been pragmatic, seeking to examine the practical consequences of the organisational activities in crisis response efforts, and what the implications for the future (if any) can be. In this section, we discuss the links to practice through the reflexive and critical analysis of how the processes, and steps evolved in the case study. We sought to understand what it takes for the lessons learnt during a crisis to trigger transformative thinking, i.e., for the novel approaches to influence the enactment of future routines and adaptive capacity of the sociotechnical system. This focus is consistent with what Amir and Kant (2018) denote as transformability – the ability of sociotechnical systems to shift from one form to another in the aftermath of shock and disturbance, for which relations, structures, and practices are crucial.

5.1 Capabilities required for innovative response and transformability

The existing **informational relations** among the PFI team, the municipalities, the hospital, and the vendors were central when mobilizing the ad hoc expert team to develop the COVID-19 solution. However, the existing relations also encompassed the cross-municipality regional coordination group, for whom the PFI team worked. The PFI team reports that they did not manage to engage or mobilize this group to support the implementation of the novel COVID-19 module, and negotiations related to the PFI option had to happen with each municipality. In these discussions, the outcome depended on the situation in the municipality, perception of need at the time, and contingent factors. Most likely, implementation success would have been strengthened if the capability to make joint, strategic decisions on crisis response had been present. We also saw missing relations in relation to the GP-oriented solution (version 2) that was not implemented as there was no collective representation of the various GP to negotiate and coordinate with.

In terms of the **sociomaterial structure**, the flexibility of the digital infrastructure was central. Specific system capabilities connected to the pre-existing patient-facing infrastructure were leveraged in the repurposing of the digital technology: 1) the flexibility of the solution to design a novel algorithm to collect other data; 2) to incorporate new measurement devices; 3) to build a downloadable software application with a self-registration system to replace manual enrolment by health personnel; 4) develop a novel BYOD service; 5) to develop a prototype for use without TMC follow-up; 6) and the availability of physical and organizational call-centres with healthcare personnel. These qualities of the sociometrical structures enabled the creation of novel and highly scalable services, with lower operational costs and simplified logistics. Some desired and potentially useful features were not realized, such as integration into the GP's electronic health records (EHR) systems and integration of third-party technologies, such as a decision-support system, which would further reduce the work burden and increase capacity in the health service. Going a step further would be to consider a differentiated feedback model which would be useful in the automated categorization of patients according to preference and disease severity. The interviewees are unanimous about the need for technical flexibility in the light of future pandemics with unknown factors regarding mechanisms of contagion, symptoms, risk factors, and progress of the disease. Knowledge will continue to develop along with the pandemic and will need to be fed back to shape the response - this implies that ongoing flexibility and adaptation are a necessity.

In terms of organizational **anticipatory practices**, firstly, we observed that the predefined pandemic crisis response strategies were inadequate and needed improvised adaptation. When the organizations adapted their existing health services they seemed to cater for a worst-case scenario, focused on limiting

exposure and minimizing the overall impact of the crisis. This response mindset seems to have factored out recognition of the potential viability of the COVID-19 module. The challenges in the implementation described by the project team indicate that some of the internal organizational structures lack sufficient anticipatory capacity. Different opinions and decisions are of course legitimate, and e.g., decisions not to use the system may be well founded and justified. We argue that this variation in approach demonstrates how the anticipatory practices unfold differently in respect to timing and strategy. While the municipalities and hospital are crisis oriented and maintain a propensity for a short-term coping solution to pandemic related constraints, in contrast, the PFI team stress how the short-term learnings from use of the system during the pandemic may sustain expanded use of the PFI in the future. And so, robust learning and feedback loops are central to securing the achievement of both short-term recovery and long-term innovation. Learning is distinguished from adaptation based on the environmental experience to predefined structures – learning forms new emergent structures that are previously unknown (Johnson & Gheorghe, 2013). This might have been better supported if some forms of anticipatory practices were deliberately cultivated and integrated into decision-making processes.

5.2   Implications for theory

While Duchek (2020) details organizational capabilities for organizational resilience, she does not specifically address transformability. Also, when Amir and Kant (2018) define sociotechnical resilience as transformability, they do not concretize this into what capabilities are required for the relations, structures, and practices to work. In our combination of these two lenses, we have attempted to draw out learnings related to capabilities for transformation in sociotechnical configurations. It is important to note that the notion of sociotechnical transformation captures the changes at multiple time scales – both changes due to repair and changes from adaptation to the new environment. This transformation, caused either by repair or adaptation, may involve organizational and institutional reconfiguration in terms of informational relations, sociomaterial structures, and anticipatory practices.

The qualities of information relations, sociomaterial structures, and anticipatory practices are confirmed to be central in our case study. In terms of the more concrete capabilities required for transformability, we contribute by reframing the role of the capability of anticipation. While Duchek's (2020) model positions anticipation as the initial stage (preparedness for a crisis), we argue that this is a crucial feature also in the final stage of her model – that of adaptation, reflection, and change. Anticipation of the next crisis should feed into the decisions made, and forward-looking considerations should inform which decisions are made about reconfiguring practices and structures. This 'reflective anticipation' that is partially observed in our case is a representation of how transformability is sustained beyond the immediate crisis recovery period, and shapes future entities. Another contribution concerns the sociotechnical or sociomaterial infrastructure, to which Duchek's (2020) model of organizational capabilities pays little attention. Our case demonstrated that the qualities of the pre-existing sociomaterial infrastructure, in particular its capability to flexibly be reconfigured and extended, were crucial for the innovative response. Also, in the further development during the crisis, flexibility in the form of optionality was built-in, an attribute of embedded flexibility that facilitates further innovative activities should the need arise.

Our analytic approach illuminates how the organisations deep structures maintain relative stability throughout the crisis, with much of the reconfiguration occurring within the surface structures. This shapes as a good lens to scrutinise sociotechnical change. The sociotechnical system experiences sustained instability over a period, and does not quite stabilise, instead, remaining in a quasi-equilibrium while the surface structures continuously shape and shift from the original configuration. It is difficult to imagine a scenario where things simply 'return to what they were' (equilibrium). We concur with Fischer and Baskerville who assert "the pursuit of agility and the accompanying prevalence of fast-changing technologies have led to increasingly unstable environments…and periods of relative equilibrium in IS have grown shorter, less frequent, and unreliable" (Fischer & Baskerville, 2022). The future seemingly demands modelling of sociotechnical systems where stability is nothing but a fleeting moment and rather embrace the dynamism of transforming only from quasi-equilibrium to unstable equilibrium, to deliver the necessary stability, flexibility, and adaptability (Empson & Alvehus, 2020).

Another conceptual frame in which to understand the case might have been the notion of antifragility, a notion that subscribes to living in a world surrounded by unknowns, and designing our technologies with an inclination to thrive under external threat (Abbas & Munoz, 2021; Gorgeon, 2015). Antifragility, an approach that is based on the possibility of positive outcomes following stressful events or hazards. It is essentially a system's expansion in capability to thrive because of stressors, shocks, noise, faults, attacks, or failures (Taleb, 2012). We see elements of antifragile behaviour of the various actors in the context of this crisis. Such antifragile behaviour is deemed necessary for innovation during a crisis, however, it not only yields positive results during the crisis but is retained in the organization's skill repository. Developing antifragility requires cultivating the organizational capability to learn from internal and external stressors (Taleb, 2012) and we see a synergy between this and our empirical study.

6 Concluding remarks

We conclude that the response of the healthcare system during the pandemic was characterized by a mix of actions: some reactive with a short-term and problem-solving orientation, others more proactive with a longer-term and preparedness orientation. Pre-existing informational relations were utilized, however, additional use of these to also make joint strategic decisions would have been necessary for a fuller implementation of the COVID-19 module. The flexible and reconfigurable sociomaterial structures of the pre-existing digital platform, service, and infrastructure were central in facilitating the crisis response in the first place. However, also here we see the sketched and desired possibilities (e.g., for better integration into the EHR systems in use, as well as the un-realized automated monitoring possible in version 2) as an indication of further, unrealized potential. In addition to the prerequisite of a flexible digital infrastructure, the deliberate application of anticipatory practices appears to be of utmost importance. These were found primarily in the PFI team but are indicative of capacities that have the potential to support wider sociotechnical transformability.

While our study presents relevant insights for understanding what is required for transformability of sociotechnical configurations, it also has limitations. Firstly, our study and analysis are limited to an outsider's view of the actions ongoing in one region, while the real developments emanating from continued usage and changes in pandemic strategy are much richer than we can account for. Secondly, although other aspects of health infrastructure such as pandemic surveillance, contact tracing, testing logistics, etc. are relevant, these are not within the scope of this study.

To study challenges and crisis response can help us address what the future skills sets required for facing uncertainties may look like. The ability of humans to improvise, adapt and learn will be crucial, however these improvisations, adaptations and learning happen within the sociotechnical systems in which we are embedded. Steve Jackson (2014) writes about "broken world thinking" and highlights how we exist in an "always-almost-falling-apart world". He asks: "what happens when we take erosion, breakdown, and decay, rather than novelty, growth, and progress, as our starting points" (ibid., p. 221)? and we find such a question valuable when considering the uncertain future. A mindset that understands and accepts that "the world is always breaking; it's in its nature to break" (ibid., p. 223) may facilitate smoother adaptation and transformative approaches to an always evolving world. This may come across as a pessimistic or defeatist perspective, but this is only the case if we overlook that there is also a responsive world that is constantly shifting, reinvented, reconfigured, and reassembled into new combinations and new possibilities. The capabilities for taking advantage of these possibilities are important to cultivate, and we have drawn attention to these in our study of a crisis response and transformation process.

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