Elicitation, analysis and mitigation of systemic pandemic risks

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ABSTRACT

The Covid-19 pandemic has disrupted the health care system and affected all sectors of society, including critical infrastructures. In turn, the impact on society's infrastructures has impacted back on the health care sector. These interactions have created a system of associated risks and outcomes, where the outcomes of risks are risks themselves and where the resulting consequences are complex vicious cycles. Traditional risks assessment methods cannot cope with interdependent risks.

This paper describes a novel risk systemicity approach to elicit and mitigate the systemic risks of a major pandemic. The approach employed the internet-based software *strategyfinder*™ in workshops to elicit relevant risk information from sixteen appropriately selected experts from the health care sector and major sectors impacted by and impacting back on the health care sector. The risk information was processed with powerful analytical tools of *strategyfinder* to allow the experts to prioritise portfolios of strategies attacking the vicious cycles.

Keywords

Systemic risk, cascading effects, vicious cycles, risk system analysis, risk mitigation.

INTRODUCTION

Responding to the Covid-19 pandemic and preparing toward further pandemic waves is extremely complex. The Covid-19 pandemic has raised a challenge where "everything is connected with everything", to paraphrase the nature of interdependence in complex systems (Figure 1). Numerous factors outside of the health system impact the management of the pandemic, e.g., mass gatherings, travels, transport, schools, …, and vice versa: the pandemic itself impacts on numerous outside factors, of which many have causative effects on the pandemic and other health aspects (such as diverting resources needed for other critical cases toward the pandemic). These factors have the potential to deliver harm, although for most of them the probability of their occurrence cannot be computed numerically.

Hence, one must prepare for and respond to the direct and indirect consequences of the Covid-19 pandemic by considering risk as "a phenomenon that has the potential to deliver substantial harm, whether or not the probability of this harm eventuating is estimable" (Lupton, 2013, p. 10).

The Covid-19 pandemic is a highly complex dynamic system. It contains vicious cycles, i.e., complex chains of risk factors that reinforce themselves through a feedback loop.[1] See Figure 2 for an example of a vicious cycle.

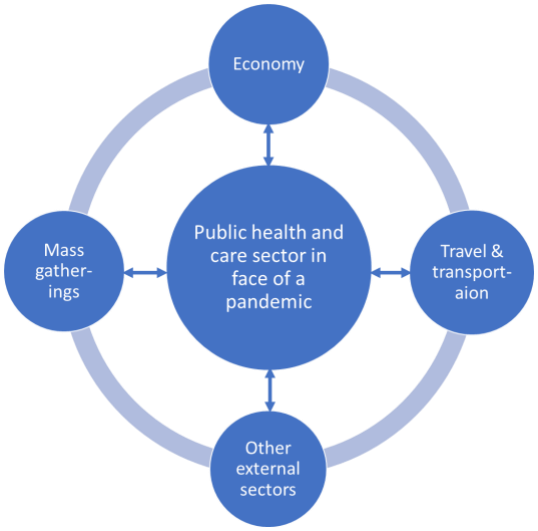


Figure 1. Preparedness and response to a pandemic goes beyond chains of effects within the public health and care sectors. These sectors are influenced by external sectors, inducing complex feedback loops of reciprocal effects.

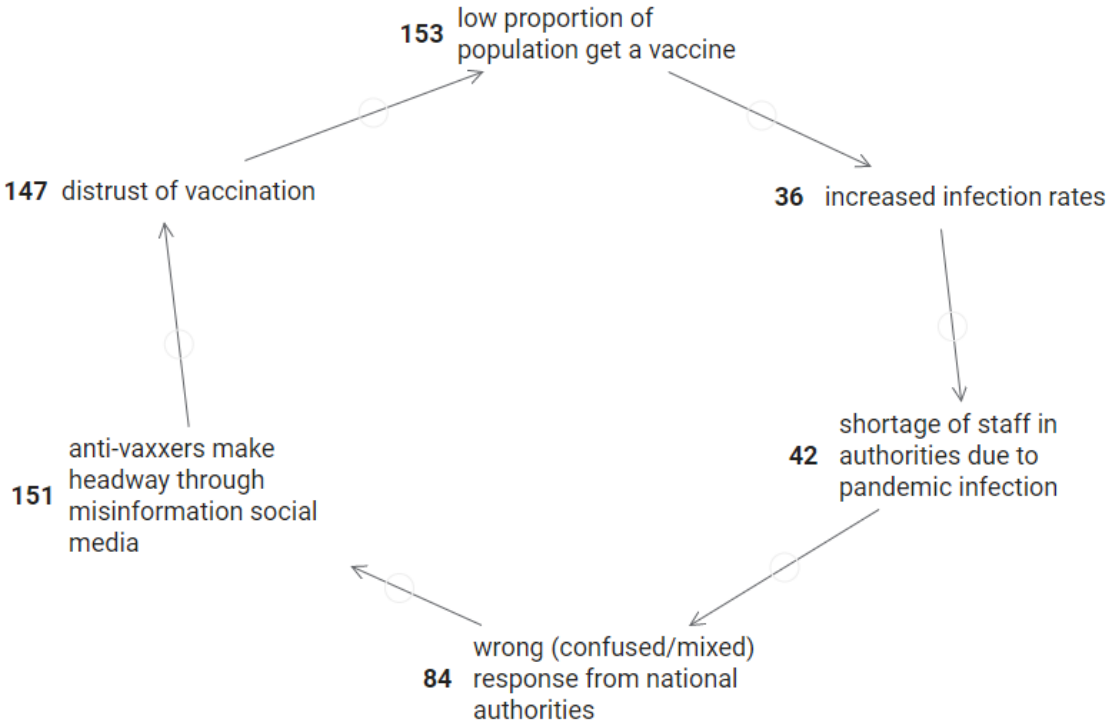


Figure 2. A simple vicious cycle related to vaccination – the arrows represent the direction of causality. This vicious cycle is part of a systemic risk model consisting, in round numbers, of 180 risk factors. The double headed arrow 36↔42 expresses that 36 causes 42 (making this influence part of the vicious cycle) and that 42 causes 36.

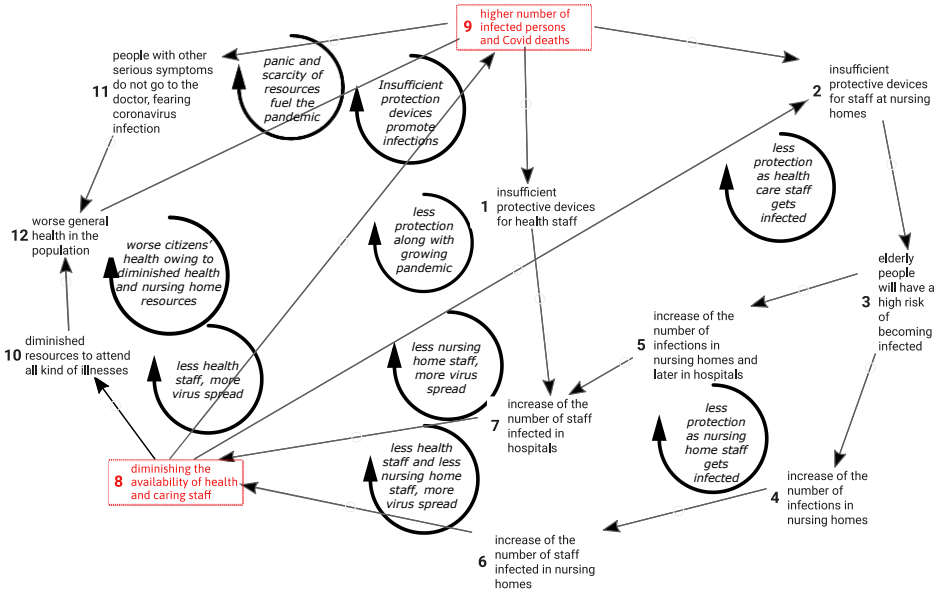
Several vicious cycles can be interconnected, which drive complex, compounded effects. Vicious cycles must be

[1] Feedback occurs when outputs of a system are routed back as inputs as part of a chain of cause-and-effect that forms a loop. See Ford, 2020, Ch. 9.

detected and understood, and they must be responded to with measures that are anchored in a proper understanding of resulting dynamic complexity. Quoting Senge (1992), dynamic complexity is characterised by "…cause and effect are subtle…the effects over time of interventions are not obvious. Conventional forecasting, planning and analysis methods are not equipped to deal with dynamic complexity."

Very important and to the point, the existing methods for risk analysis and risk mitigation are inadequate since they do not capture the causal interdependence between risks. Solarz et al (2020) argue for understanding the holistic nature of the Covid-19 pandemic, and they suggest that "in the long run, it will be possible to monitor the pandemic via an integrated, holistic system of systemic risk management". Amaratunga et al. (2021) state that "Current policies that are designed to address conventional risks are unable to capture and deal with the complexity and interconnectedness of systemic risks. Hence, a policy mechanism that facilitates 'systemic risk governance' is much called for". However, neither Solarz et al. nor Amaratunga et al. have accomplished methods or policies for doing so. Risk is often referred to as the probability of an event occurring multiplied by the consequence of that event (ISO 31OOO, 2018; DHS Risk Steering Committee, 2010, p. 35 Probabilistic Risk Assessment). This definition is reflected in risk assessment tools such as a Risk Register (Project Management Institute, 2017) where the likelihood and the impact of individual risks are considered. Although Risk Registers are commonly used, they promote consideration of the impact of risks in isolation from one another without taking account of the interactions between risks. These interactions create a network, or system, of associated risks and outcomes, where the outcomes of risks are risks themselves, and where the resulting consequences can be extremely complex. Risks are a system where a single risk can cause a plethora of other risks, inducing vicious cycles of risks (Ackermann et al., 2007).

In the case of Covid-19 one has a system of risks where risks in different sectors (health, business, social



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with a higher-than-average risk of fatal outcome, will have a high risk of becoming infected. It will increase the number of infections in nursing homes, and later in hospitals. In turn, it will increase the number of staff infected, diminishing the availability of health and caring staff, and making the lack of protective devices even more acute, owing to the higher number of infected persons. People with potentially serious health symptoms (e.g., cancer), do not go to the doctor, fearing coronavirus infection, thus worsening the general health in the population. Related to this, there is also the waiting list problem. The health conditions got worse owing to the postponement of surgical operation (many doctors were not available for not-COVID-19 related operations).

The example in Figure 3 is a comparatively simple subsystem of the challenge to assess and mitigate pandemic

risks. Few would guess that the subsystem induces 17 vicious cycles, half of them nested, threatening loss of control unless properly mitigated. Seventeen vicious cycles are already a major challenge. Our pandemic risk model has, in round numbers, 180 risks factors, yielding over 4 million of vicious cycles, most of them highly nested. It follows that the management of such a complex challenge cannot be met with conventional strategies addressing isolated risks, even if the strategy targets ten, twenty or even thirty identified risks. Rather, portfolios of strategies targeting multiple risk factors in highly compounded vicious risks networks are needed.

Hence, the system of risks conjured by Covid-19 has a high level of dynamics complexity, reinforcing the urgency of the recent call in the risk literature: "…substantial research and development to obtain adequate modelling and analysis methods – beyond the 'traditional' ones – to 'handle' different types of systems… which are complex systems and often inter-dependent." (Aven, 2016).

The Norwegian government appointed the 24th April 2020 a committee of experts to evaluate all relevant aspects of Norway's management of the Covid19 pandemic. The committee delivered 14th April 2021 a report to this effect (Koronakommisjonens rapport (NOU), 2021, in Norwegian). On p. 26 the committee lists the seventeen main findings. Main finding no. 1 concludes that all in all the government's management of the pandemic has been good (Norway is among the European countries with lowest mortality from the pandemic and among the least affected economically). The second main finding criticises the government for insufficient preparedness, despite the fact that the Norwegian Directorate for Civil Protection had evaluated a major pandemic as the most probable and most serious national crisis.

The third main finding reads like this (translation from Norwegian by JJG): "In its preparedness work, the Government has not considered how risk in one sector depends on the risk in other sectors. A preparedness system based on each sector assessing its own risk and vulnerability fails when no one has taken responsibility for assessing the sum of the consequences for society as a whole. There is a need to develop a cross-sectoral system that captures how the risks in the various sectors interact with each other. This is a learning point for emergency preparedness in general." This paper presents the methods and the preliminary findings of the Systemic Pandemic Risk Management (SPRM). Our project targets precisely a cross-sectoral system that captures how the risks in the various sectors interact with each other, and the SPRM's methods are indeed able to be adapted to preparedness in general, i.e., beyond pandemics.

The SPRM project is an innovation project with private/public participation funded by the Research Council of Norway. Project partners are the Norwegian company Stepchange AS (project manager), the municipality of Kristiansand (capital of Southern Norway); the Hospital of Southern Norway (Sørlandet Sykehus); the Centre for Integrated Emergency Management (CIEM) at the University of Agder, Norway; the Center for Research and Training in Disaster Medicine, Humanitarian Aid and Global Health (CRIMEDIM), at the Universitá del Piemonte Orientale, Italy; and the Center for Disaster Medicine and Traumatology (Katastrofmedicinskt Centrum – KMC), affiliated with Linköping University, Sweden. Innovation projects funded by the Research Council of Norway target the development of commercial applications requiring research and development activities. The SPRM project will provide state of the art tools and methods to improve preparedness and response to pandemic crises within the health and care sector, but also in any public organizations and in enterprises vulnerable to economic consequences of pandemics, such as airlines, cruise lines, insurance companies, etc.

The fundament and point of departure of the SPRM project are methods developed through decades of research on strategic management and systemic risk assessment and mitigation for engineering projects. Among the numerous references we mention Williams et al., 1997; Ackermann, et al., 2007; and Ackermann et al., 2014. Recently, the risk systemicity approach was extended to societal resilience (Pyrko et al., 2019). The research on strategic management and systemic risk assessment and mitigation employed tools known as Group Explorer and Decision Explorer (Eden & Ackermann, 1998) that have recently inspired the internet-based tool *strategyfinder*™ (https://strategyfinder.pro/).

The extension of the risk systemicity methods to pandemic risks impacting and being impacted back by several critical infrastructures, understood as assets that are essential for the functioning of a society and economy, enters the territory of systems-of-systems. A system-of-systems is a large and distributed network of component subsystems which are themselves complex and autonomous. The extension of the risk systemicity methods to the pandemic system-of-systems poses several major challenges:

- Increase in the number of risks and the interrelations among the risks;
- the increase in risks inducing an even larger increase in the number and impact of the vicious cycles;
- the increase in vicious cycles causing a significant increase in the complexity of the risk scenarios;
- which in turn increase the challenge to identify powerful portfolios of strategies to disable the most potent risks.

To explore and identify the issues to be implemented as tools and methods to improve preparedness and response to pandemic crises within the health and care sector, the first work package of the SPRM project conducted a risk systemicity research and analysis of the Covid-19 pandemic. Thereby, interdisciplinary experts participated in six risk systemity workshops facilitated by experts in risk systemicity analysis and strategy development with the online tool *strategyfinder*™. The selected scenario was based on the expected pandemic threats facing Southern Norway (the Agder County). The interdisciplinary participants in the workshops were experts from the capital of Southern Norway (Kristiansand) and the Hospital of Southern Norway in Kristiansand.

By conducting a systemic risk assessment of the Covid-19 pandemic the first work package of the SPRM project, systemicity research and analysis of the Covid-19 pandemic, provided insights that will be used in the work packages 2, 3 and 4. The methods and tools (enhancements of *strategyfinder*) to be developed in the work packages 2, 3 and 4 aim at significantly easing the task of risk systemicity facilitation:

- automated risk scenario identification, which is the target of the SPRM project second work package;
- automated analysis of impacts for prioritizing, which is the target of the SPRM project third work package;
- generation of policy options writing scenarios, which is the target of the SPRM project fourth work package.

The scope of a research project like SPRM limits the scope of the systemic risk assessment of the Covid-19 in several ways:

- Since the project started 1st September 2020, seven months after the detection of the first Covid case in Norway and the deployment of national and regional teams to meet the pandemic challenge, the SPRM project's contributions are not automatically integrated into Norway's Covid strategy. Rather, the project's participants carry over the project recommendations and insights to the decision-makers.
- The project workshops require the participation of heavily engaged personal. They had to be conducted after normal working hours, i.e., adding 2-3 hours extra work. It happened several times that participants who had registered for workshop participation had to deal with urgent Covid-related problems in their normal professional role, thus hindering them to participate in the workshop. Other times, registered participants cancelled their participation in the planned workshop, but it was possible to find substitutes. Both circumstances made the project workshops less productive than intended.
- Within the scope of an innovation project the number and the duration of the workshop cannot match the effort that would be required for a full-scale risk systemicity assessment and development of strategies. Thus, the actual outcome of the first work package is not a full-fledged analysis of systemic risks. Rather, it should be considered as proof of concept that the project methods can be applied to a major pandemic.

The remainder of this paper is organised this way:

- Section RISK SYSTEMICITY METHOD describes the risk systemicity method and the tool *strategyfinder*™ supporting it.
- Section IDENTIFYING AND SELECTING APPROPRIATE INTERDISCIPLINARY ROLES describes the approach to ensure that the pandemic risk systemicity workshops focused on health care can elicit on the most relevant know-how from interdisciplinary experts for the project's objective.
- Section RISK SYSTEMICITY WORKSHOPS provide a high-level description of the workshops and their progression along with analysis going on between workshops.
- Section ANALYSIS FOR PRIORITISING RISK MITIGATION describes how to determine the systemic risks that are likely to be the most relevant to mitigate.
- Section DEVELOPING EFFECTIVE MITIGATION STRATEGIES focuses on method and outcomes to this effect.
- Section "CLIENT" FEEDBACK reports on the usefulness of the project outcomes for the clients (understood as the project partners Kristiansand municipality and the Hospital of Southern Norway).
- Section CONCLUSION AND OUTLOOK discusses the risk systemicity approach of this project in the light of the Top-Hazards Approach to disaster risk reduction and describes how the outcome of the SPRM's first work package serves as a platform for the project's main objective and how the project work packages 2…5 build upon these outcomes.

RISK SYSTEMICITY METHOD

The nature of any major pandemic requires that the development of effective strategies for risk mitigation must

involve interdisciplinary thinking and strategy implementation – working across traditional silos.

The SPRM project uses a special collaborative software to elicit and collect wisdom, experience, and knowledge from interdisciplinary experts in a structured way. This software – *strategyfinder*™ – allows the participants to 'meet' via the internet and work on a causal map of the interconnected risks. Each participant can add material to the risk map. The participants add links between the views representing causal influences, which often lead to discovering feedback loops (vicious and virtuous cycles, and balancing/controlling feedback loops). Changes and additions made to the map can be seen by all participants.

The map shows the risks and the causal links presumed to exists between them. In some respects, these maps can be seen to be similar in form to 'cognitive maps' and causal maps can be amenable to many of the methods used to analyse cognitive maps (Eden 2004) However, there is an important distinction between cognitive maps and the causal maps created in this project. A cognitive map is intended to be a map of cognition, cognition belongs to an individual not a group (Eden 1992). A group map merges the thinking of all members of the group and is highly unlikely to be representative of any individual members cognition. What we have been constructing are cause or causal maps.

The system of risks presented in a causal map format then allows participants to i) explore and validate a pre-prepared generic map of the system of risks and consequently make it appropriate to their location and to the time horizon they wish to consider, and ii) develop impactful strategies that are also practical. The *strategyfinder* software has powerful tools for analysing the risk map, to detect feedback loops and find the most central parts of the system, to rate and to add preferences, and to guide the participants during this strategy development process towards realistic actions and goals. A facilitator works with the group to help ensure that the different individual perspectives are structured to reveal significant causal chains of argument that allow for further reflection, extension, and debate amongst group members.

During the SPRM first work package the interdisciplinary expert group met for two 2 hrs workshops on two occasions during December 2020, and for four 3 hrs workshops on four occasions during January and February 2021. Each participant can contribute from any location where they have access to a computer and internet connection. Indeed, the workshops involved participation from Norway, Sweden, and the UK.

IDENTIFYING AND SELECTING APPROPRIATE INTERDISCIPLINARY ROLES

Gathering a willing and appropriate group of participants is crucial. The SPRM project is concerned with the impact of a pandemic on healthcare. That impact – the risks associated with it – cross disciplinary boundaries. The nature of a pandemic implies that the implementation of strategies to mitigate key risks will involve teams across many departments and silos.

To make the tool/method as effective as possible we have identified a recommended mix of participants. We settled on a maximum group size of 16 persons to i) enable a good interdisciplinary mix, but also ii) keep the group size to an effective number, given the different place-same time way of working and the use of *strategyfinder*.

The process to identify participants involved five iterations.

1. The first iteration involved five members of the SPRM project with different backgrounds and perspectives. They suggested 51 relevant participants (or rather roles).
2. In the second iteration the perspective (topics) that the proposed participants would bring was mapped out.
3. In the third iteration we mapped the identified topics and the potential participants that might be able to contribute with relevant expertise to the topic.
4. In the fourth iteration 13 advisors, including the five persons from the first iteration augmented with additional experts from Norway, Sweden, Italy, and the UK, were invited to i) comment on the list of participants and seek to narrow down/prioritise, ii) add new ideas for participants, and iii) add missing topics and link participant suggestions to the new topics.
5. In the fifth iteration, the map created from iteration 2 was updated in the light of responses. The total number of suggested participants had increased to 65. Then, the participants were scored for each topic based on i) the number of topics that the respondents saw that the potential participant was able to contribute to, ii) the number of respondents prioritising the potential participant, and iii) the number of topics that the map indicated a potential participant might contribute to. These three indicators thus took account of the respondents' views about priorities and the overall data. To provide a 'final' score these three scores were multiplied together. The final score provided an indication only of possible priorities. In addition, there was the constraint of ensuring that there was at least one participant nominated for each topic.

The fifteen top recommended participants are:

- coordinator for crisis management for the municipality, city, or region
- medical doctor responsible for pandemic response
- senior hospital manager/ chief medical director
- representative of business in the Region: for example, Chamber of Commerce CEO
- main transport operator (e.g., lorries, rail, ferry)
- representative of hospital Human Resource Management
- care home management (public and private)
- leader of the communication for region/city
- city project manager: Impact on the health and care sector
- senior manager in social services for the Region
- senior Police Officer
- airport chief (contact with all the airlines)
- politician (local and/or national)
- expert in human behaviour (of different groups)
- expert on medical supplies to country/ region

In addition, we added the role of a "remarkable person", defined as

- a person not in contact with any other participant;
- likely to create an 'aha' from other participants;
- often an academic bystander/observer;
- likely to take an intelligent, well-argued, but 'off-the-wall' surprising perspective.

Given it is unlikely that one will be able to gather precisely the recommended group of participants, it is important to appreciate the contributions they are each expected to make to the workshops. E.g., we did not get a senior hospital manager/chief medical director to attend the workshops. The replacement that covered the required contributions was the specialist emergency medicine and manager at the Accident &Emergency department at the Hospital of Southern Norway.

RISK SYSTEMICITY WORKSHOPS

The first workshop, conducted 10th December 2020, resulted in a map of risks along with proposed causal influences between risks.

Participants worked independently, adding risks within the health care sector and externally in sectors being affected by and affecting the health care sector. They added the risks blindly (not seeing the risks added by the other participants).

After making the screen with all the proposed risks made visible to all, the participants added arrows representing causality. A single arrow from A to B, A→B, means A causes B. Example on Figure 4, p. 8: the arrow going from statement 24 to 63 in the lower-left corner. A double arrow between C and D, C↔D, means C causes D and D causes C. On Figure 4: the double arrow going from statement 20 to 63 and vice versa in the lower-left corner.

During the seven days between the first and the second risk systemicity workshops, the SPRM analysts employed *strategyfinder* to detect and classify vicious loops, to create views of the risk systemicity model and to prepare tasks for the second workshop. Each view expresses a perspective obtained by showing the most relevant risk factors for the perspective and hiding risk factors of less relevance. Added information is provided using special *strategyfinder* styles. Figure 5, p.9, shows a part of the risk system related to the shortage of hospital workers – most of the risks on this view have causal links to other risks not shown. [KEY: ***/bold means these risks are in most of the feedback loops in the total risk system; background of grey means they are seen as long term outcomes; pale orange background indicates they are part of a feedback loop on this view – for example, 20 cause 97 which causes 20, and 20 causes 97 which causes 96 which causes 20, and 20 causes 63 causing 96 which causes 20; and note one 'balancing loop' where fewer people travelling to work (101) causes less fear (87) which causes more people travelling to work].

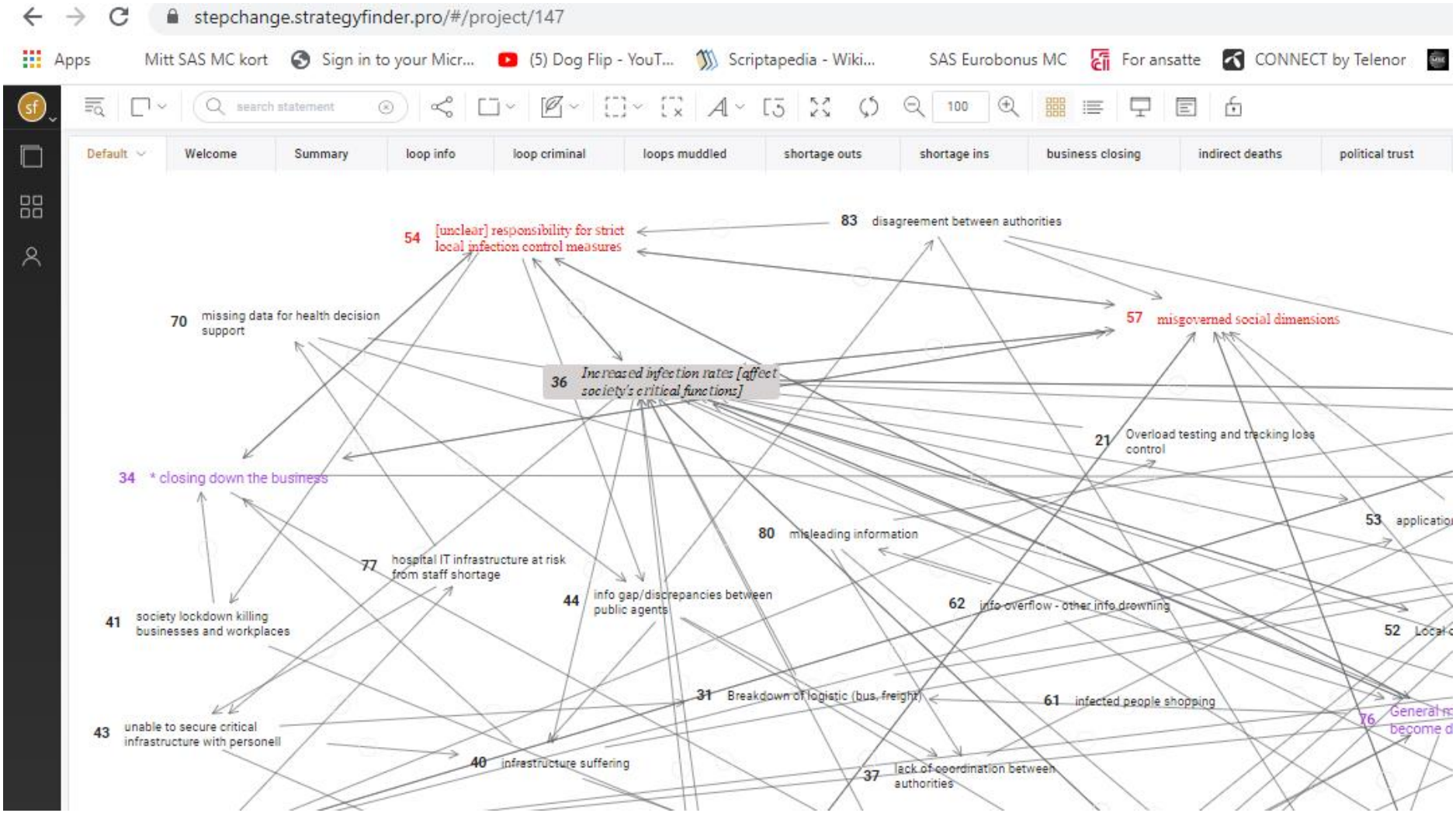


Figure 4. Part of the causal map of systemic pandemic risks at the end of the first risk systemicity workshop. About 180 risks were identified by the expert participants

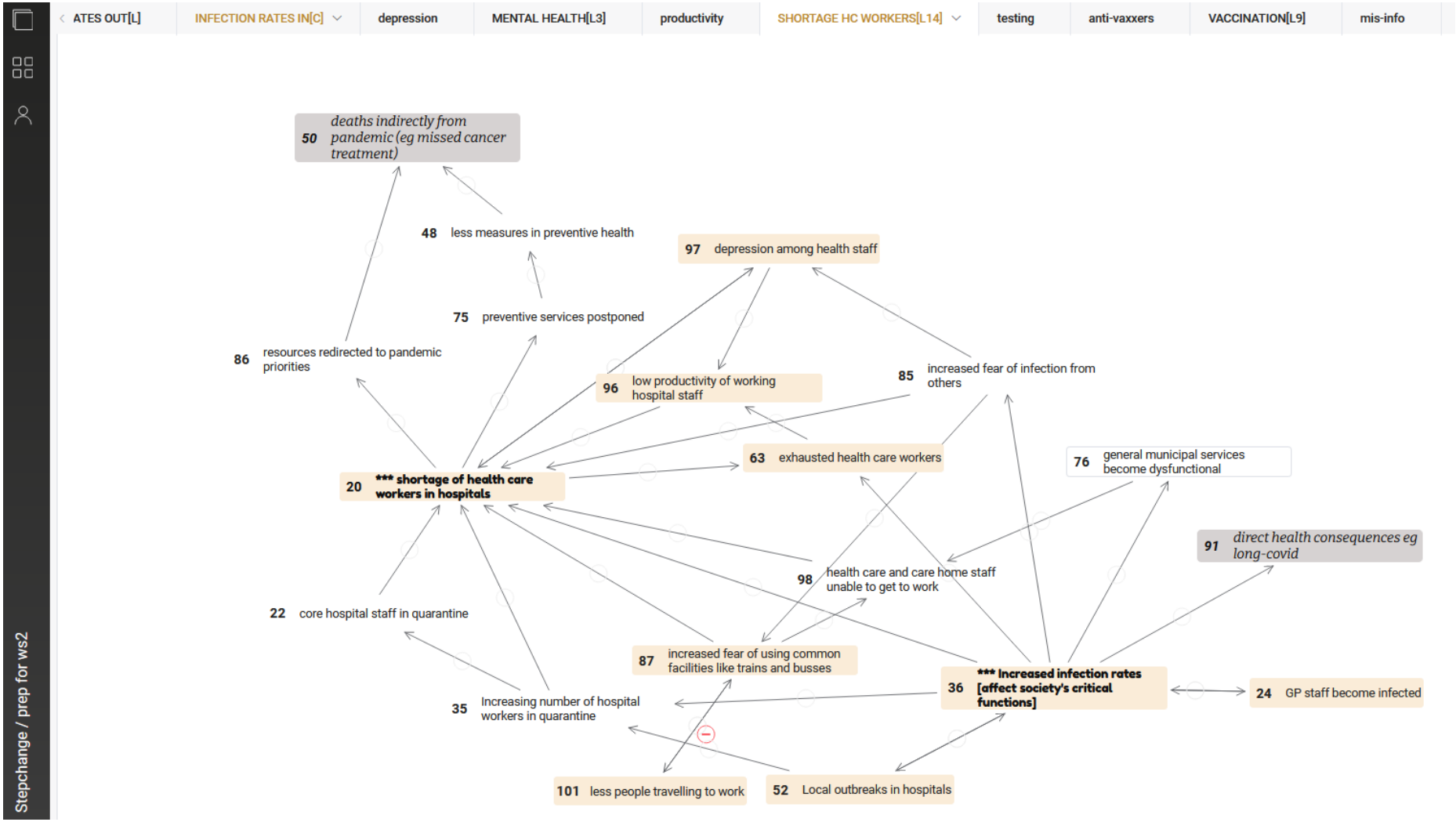


Figure 5. View showing selected risks with strong impact on the availability of health care workers in hospitals (risk factor #20). For details, see main body text.

Some *strategyfinder* views were intended for analysis (internal use). Other views were intended for further usage in the second workshop. The view shortage of health care workers in hospitals has been selected. The resulting risk system on the canvas shows risks strongly affecting health care workers shortage.

The activities in workshop 2 were validation of important views (checking causality, adding missing risks and their causality using *strategyfinder*). To undertake this validation process, the group examined and validated risk sub-systems; this involved the participants proposing and arguing their case for deleting risks (unusual outcome) and also changing causal links. This often involves debate about evidence vs. experience vs judgment, etc.The outcome of workshops 1&2 was a generic pandemic systemic risk model.

The last four workshops addressed a scenario of high relevance for Agder County, i.e., Southern Norway (Figure 6).

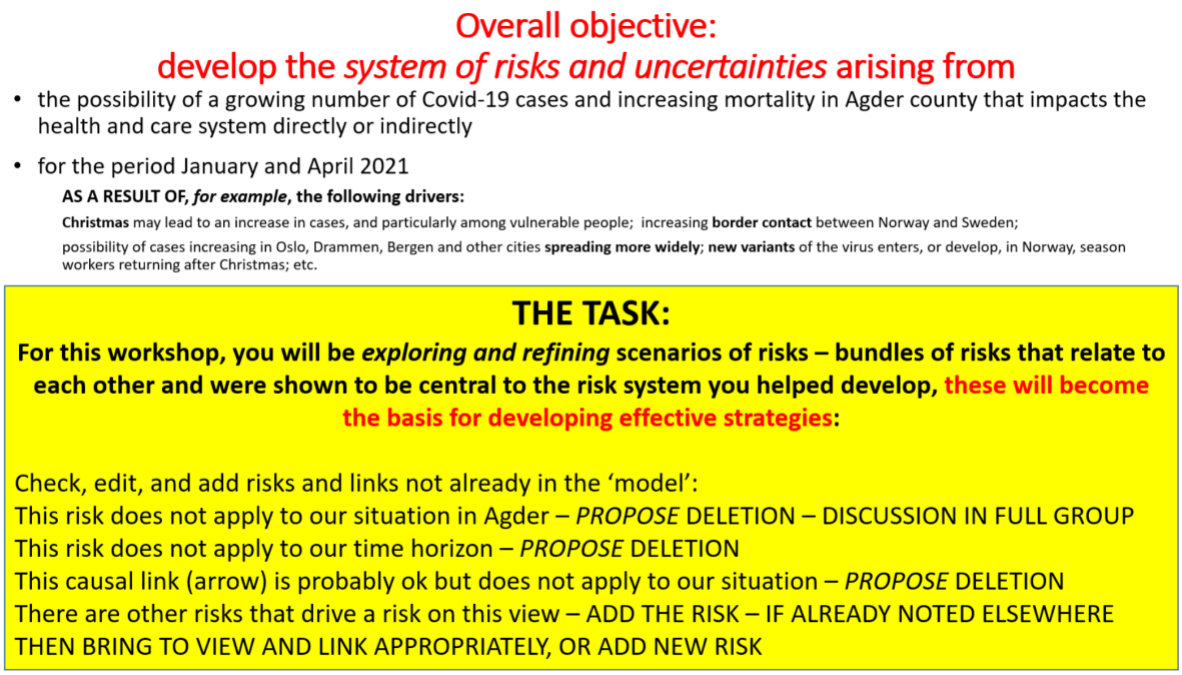


Figure 6. Scenario for workshops 3-6

The outcome of workshops 3-5 was a validated localised pandemic systemic risk model ready to be analysed for prioritising risk mitigation and for developing effective mitigation strategies.

ANALYSIS FOR PRIORITISING RISK MITIGATION

The objective of the analysis of the risk system is to find those risks that if mitigated would be likely to have the biggest impact in terms of reducing infections and deaths. It is these risks that should become the focus of strategy development.

The risk system is made up of over 4 million of feedback loops – mostly vicious cycles. The feedback loops are all linked either because they are nested loops (see figure 3) or because of causal links from one system of loops to another. The task for the analysis in preparation for the strategy development workshops involves three steps: i) find all of the feedback loops, ii) find the risks that appear in the most feedback loops, and iii) find which causal links, if deleted, would reduce the maximum number of feedback loops.

Strategy development can then focus on mitigating the risk that appears in most feedback loops – thus, in effect 'deleting' this risk from the risk system and so maximally collapsing the risk system, and/or find a strategy that will stop the causal link (discovered in (ii) above) from working – find a strategy to 'delete' the arrow, or reverse its causality, or convert a vicious loop into a balancing feedback loop contributing to mitigate the associated risks.

Strategies that do not address the most potent risks with a portfolio of strategies acting on the most potent risks simultaneously are not effective enough. The "pandemic fire" simmers further through the active potent risks that remain showing up with a roller coaster of pandemic waves.

After each strategy-development-workshop the analysis was repeated by analysing a 'corrected/updated' risk system model which has the mitigated risks taken out (on the basis that the mitigation strategy has been successful,) and any causal link strategies taken to be implemented successfully. This analysis reveals the next

priority risks for which strategies should be developed.

These analyses are, of course, non-trivial and require the use of computer-based analysis techniques for them to be undertaken. The analyses are designed to enable a group to:

- Focus on the dominant vicious cycles – the ones with risks that occur in most loops.
- Get rid of the vicious cycle by attacking one of the causal links in the cycle.
- Attack the risk that is at the core of the vicious cycle – in most loops by i) checking what drives the loop (in-arrows), ii) being creative.
- Flip a vicious cycle into a virtuous cycle.
- Make the cycle a balancing loop – develop a strategy to turn a causal link to the opposite impact.
- Solving one vicious cycle is never enough, and often will not happen quickly enough without attacking the other dominant linked vicious cycles: mental health; shortage of hospital staff; social distancing.

DEVELOPING EFFECTIVE MITIGATION STRATEGIES

The implementation of agreed strategies is successful when the strategies are *both* i) potentially impactful – they do what they were intended to do (impact the risk at the end of arrows out of the strategy) and ii) are practical. These two criteria were used to evaluate the range of strategies suggested in the strategy development workshops. On some occasions the evaluation of strategies reveal that they are: highly impactful and impractical in which consideration is given to making them practical, and secondly when they are highly practical and have low impact then consideration is given to making them impactful.

In order to help ensure that implementation of strategies is successful, when monitoring and review the question to be asked is "have you implemented the strategy in such a manner that it will achieve xxxx…" (xxxx = impact specific risks at the end of the out-arrows). Thus, when devising an implementation plan it is crucial to ensure that everyone involved knows that part of the causal map: the statements at the out-arrows of the strategy (see Figure 8 below).

Given the above requirements for strategies, the purpose of the strategy development workshops was:

- Refine, re-evaluate and agree on a portfolio of strategies that will impact the six previously identified key risk topics: staff shortage in health care provision, mental health, social distance, trust, vaccinations, and infection rates.
- Develop strategies that are both high leverage and practical: attack the core risks with a portfolio of strategies (allowing that some will fail) – find strategies that will attack each risk in vicious cycle
- Identify the interdisciplinary teams required for the effective implementation of the agreed strategies.

Workshop participants were instructed to:

- Review each topic by i) refining existing strategies if necessary, ii) identifying missing impactful strategies, iii) evaluating the proposed strategies for their impact over our agreed time horizon – effective impact before April 2021.
- Identify those agreed strategies to which i) you personally would expect to contribute as a part of the implementation team, ii) others in your organisation would expect to contribute, and iii) other organisations /people who are not a part of the group who are needed as part of the implementation team.

To enhance the implementation of strategies, participants were requested to:

- Consider the purpose of the strategy – the arrow out – make sure it delivers.
- Think about who should be directly involved.
- Think about who should take overall responsibility.
- Think about who should know.
- Think about where any financial resources will come from.

Figure 7, p.12, exemplifies the outcome of the last workshop using, as an example, one of the previously identified key risk topics, viz. staff shortage in health care provision. The participants suggested strategies – such as #240 on the r.h.s. of the diagram along with the responsibility for the implementation (here #361).

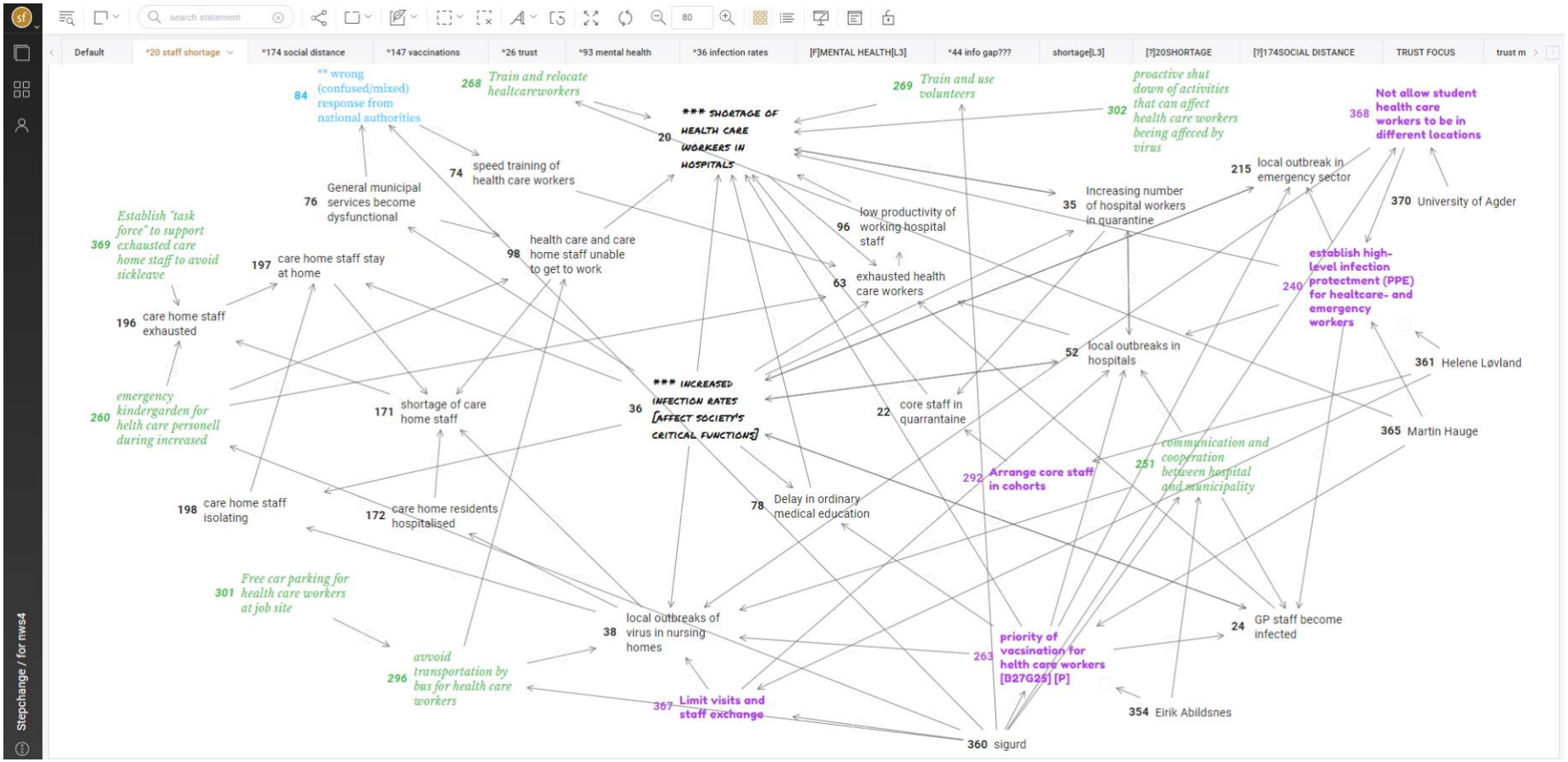


Figure 7. View 'staff shortage' after adding suggested mitigation strategies and responsibility for implementation of strategies [purple statements are key strategies – judged to have the highest impact, and those in green are subsidiary strategies – judged to have good impacts.

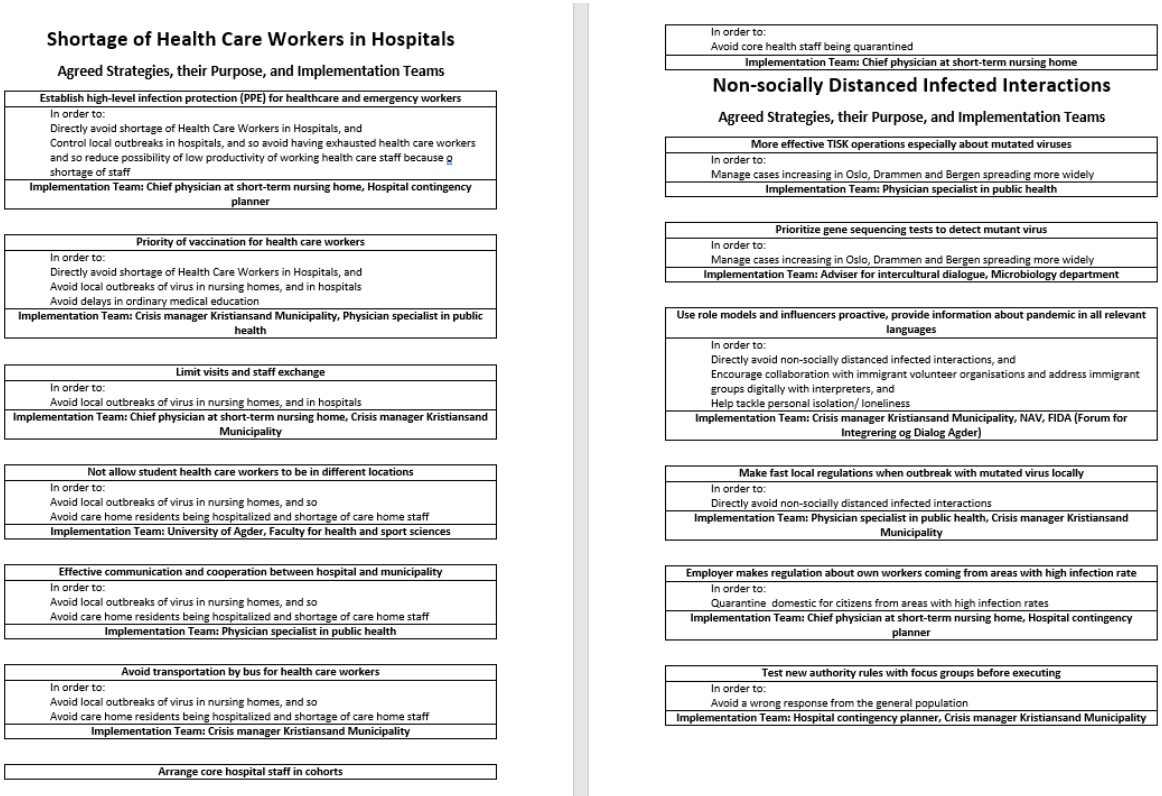
After the final workshop, the SPRM analysts use the sequence of maps developed by the group to compose a document on the agreed portfolio of strategies (Figure 8 shows the first two pages of the document). For each portfolio, the rationale of the strategy is explained in terms of its causal implications.

As indicated in the introduction (p.5), the limitations of the project did not provide enough time to exhaust the capabilities of the risk systemicity method. The strategies depicted in Figure 8 should be seen as proof of concept of what can be achieved within a few hours of concerted effort with interdisciplinary experts.

"CLIENT" FEEDBACK

Perspective from the Kristiansand municipality

The systemicity approach utilizing *strategyfinder* applied in workshops in the SPRM project goes beyond traditional risk and vulnerability analysis in that it addresses the key factors making up the complexity of the pandemic. Based on input from stakeholders representing different health care services and many other sectors affected by the pandemic, the interdisciplinary workshops provided insight into the interdependencies of the direct and indirect pandemic risks by revealing the most important vicious cycles and key risk scenarios along with the strategy to attack the vicious cycles making up those scenarios. The participants could discuss the identified risks, and the impact and possibility to cope with the identified risk on a local level. The participants reported that this made it possible to seek to reach an interdisciplinary consensus about what strategies to apply, targeting the most relevant risks during the ongoing pandemic. The identified relevant strategies, not already being implemented are to be communicated to the decision-makers responsible for efforts to mitigate the identified risks and vicious cycles. Inevitably, the workshop participants did elicit some strategies that are already implemented by local, regional, or national decision-makers, thus confirming their efficacy. The workshops provided added value by eliciting systemic strategies through a novel methodology that will allow the exploration in depth of the implementation systemic strategies in the follow-up and review process.



Shortage of Health Care Workers in Hospitals

Agreed Strategies, their Purpose, and Implementation Teams

Establish high-level infection protection (PPE) for healthcare and emergency workers
In order to: Directly avoid shortage of Health Care Workers in Hospitals, and Control local outbreaks in hospitals, and so avoid having exhausted health care workers and so reduce possibility of low productivity of working health care staff because o shortage of staff
Implementation Team: Chief physician at short-term nursing home, Hospital contingency planner

Priority of vaccination for health care workers
In order to: Directly avoid shortage of Health Care Workers in Hospitals, and Avoid local outbreaks of virus in nursing homes, and in hospitals Avoid delays in ordinary medical education
Implementation Team: Crisis manager Kristiansand Municipality, Physician specialist in public health

Limit visits and staff exchange
In order to: Avoid local outbreaks of virus in nursing homes, and in hospitals
Implementation Team: Chief physician at short-term nursing home, Crisis manager Kristiansand Municipality

Not allow student health care workers to be in different locations
In order to: Avoid local outbreaks of virus in nursing homes, and so Avoid care home residents being hospitalized and shortage of care home staff
Implementation Team: University of Agder, Faculty for health and sport sciences

Effective communication and cooperation between hospital and municipality
In order to: Avoid local outbreaks of virus in nursing homes, and so Avoid care home residents being hospitalized and shortage of care home staff
Implementation Team: Physician specialist in public health

Avoid transportation by bus for health care workers
In order to: Avoid local outbreaks of virus in nursing homes, and so Avoid care home residents being hospitalized and shortage of care home staff
Implementation Team: Crisis manager Kristiansand Municipality

Arrange core hospital staff in cohorts

In order to: Avoid core health staff being quarantined
Implementation Team: Chief physician at short-term nursing home

Non-socially Distanced Infected Interactions

Agreed Strategies, their Purpose, and Implementation Teams

More effective TISK operations especially about mutated viruses
In order to: Manage cases increasing in Oslo, Drammen and Bergen spreading more widely
Implementation Team: Physician specialist in public health

Prioritize gene sequencing tests to detect mutant virus
In order to: Manage cases increasing in Oslo, Drammen and Bergen spreading more widely
Implementation Team: Adviser for intercultural dialogue, Microbiology department

Use role models and influencers proactive, provide information about pandemic in all relevant languages
In order to: Directly avoid non-socially distanced infected interactions, and Encourage collaboration with immigrant volunteer organisations and address immigrant groups digitally with interpreters, and Help tackle personal isolation/ loneliness
Implementation Team: Crisis manager Kristiansand Municipality, NAV, FIDA (Forum for Integrering og Dialog Agder)

Make fast local regulations when outbreak with mutated virus locally
In order to: Directly avoid non-socially distanced infected interactions
Implementation Team: Physician specialist in public health, Crisis manager Kristiansand Municipality

Employer makes regulation about own workers coming from areas with high infection rate
In order to: Quarantine domestic for citizens from areas with high infection rates
Implementation Team: Chief physician at short-term nursing home, Hospital contingency planner

Test new authority rules with focus groups before executing
In order to: Avoid a wrong response from the general population
Implementation Team: Hospital contingency planner, Crisis manager Kristiansand Municipality

Figure 8. Portfolios of strategies address each key risk scenario to provide enough points of attack in case that some of the strategies fail to achieve desired effect. The picture shows such portfolios for the key risks shortage of health care workers in hospital and for non-socially distanced infected interactions.

A similar systemicity approach with *strategyfinder* is seen as being applicable without external facilitators and in other scenarios than a pandemic. This will depend on acceptance of participation in systemic thinking in workshops from relevant stakeholders and the training of local facilitators who can conduct the workshops and the analysis tools in s*trategyfinder*.

Perspective from the Sørlandet Sykehus HF (Hospital of Southern Norway)

Risk systemicity assessment with *strategyfinder* is an innovative approach representing a further development of current crisis management tools. Sørlandet Hospital HF is an institution familiar with small and large emergency events. Crisis management and preparedness is an integral part of our assignment, this also includes pandemic preparedness and management.

The SPRM project with the *strategyfinder* tool and corresponding interdisciplinary workshops have revealed a large and traditionally unredeemed success-potential in complicated crisis handling, especially with community partners. The identification of risk, potential risk-reducers, vicious circles, and stakeholders within the same tool represents a promising method for future contingency planning for small and large crises.

CONCLUSION AND OUTLOOK

The United Nations Office for Disaster Risk Reduction embraces as the current paradigm in disaster risk planning the All-Hazards Approach, even in the context of the Covid-19 pandemic. The All-Hazards Approach assumes that all disasters share characteristics that allow for generalized preparedness and planning activities. Quoting from the presentation of the webinar Disaster Risk Reduction and Health in the Covid-19 Pandemic: "The webinar will …recommend key actions to enhance the promotion and implementation of integrated all-hazards disaster risk management by all sectors and stakeholders" (WHO, 2021).

A recent publication (Peleg et al., 2021) presents strong evidence that the challenges of the Covid-19 pandemic are unique, owing to the characteristics of the cascading effects, the long duration of the pandemic and the need to prioritize risks mitigation in a hierarchical manner, which altogether make the character of the pandemic very different from other disasters. Instead of the All-Hazards Approach one must meet the pandemic challenge with a Top-Hazards Approach. The Top-Hazards Approach recognises that inherently different events require different planning and mitigation tactics, and therefore should be prioritized according to likelihood and severity in each local context. The SPRM project is free from assumptions that disasters must share commonalities. Instead, the SPRM risk systemicity workshops has targeted the hazard-specific characteristics of the pandemic according to likelihood and severity in the local context.

In this paper we described the outcome of the first work package of the SPRM project: a risk systemicity assessment of the Covid-19 pandemic with suggested mitigation strategies. The selected scenario was based on the expected pandemic threats facing Southern Norway (the Agder County). At this stage of the project the main partner engagement were experts from the capital of Southern Norway (Kristiansand) and the Hospital of Southern Norway in Kristiansand. As remarked in the introduction, the limitations of the project imply that the risk systemicity assessment and the mitigation strategies must be seen as proof of concept.

In addition to the systemic risk assessment and mitigation strategies the first work package of the SPRM project, has delivered insights that will be used in work packages 2, 3 and 4:

- WP2: Development of automated scenario identification.
- WP3: Automated analysis of impacts for prioritizing mitigation actions.
- WP4: Develop script for generation of policy options writing scenarios.

Then, in the final (fifth) work package the methods and tools will be tested and validated in Italy by CRIMEDIM, in Sweden by KMC, and in Norway in joint cooperation between CIEM, Kristiansand municipality and the Hospital of Southern Norway, in all these cases with the assistance of Stepchange AS.

As SPRM project partner, CRIMEDIM – the Center for Research and Training in Disaster Medicine, Humanitarian Aid and Global Health, Italy – is the main partner to test and validate in Italy the tools developed during the project. Having a long-lasting experience in training and aiming at its continuous quality improvement, CRIMEDIM will introduce the innovative tools right within its training activities in the next future.

The testing and validation of the SPRM methods and tools are planned for the final six months of the project, i.e., between 1st March and 30th September 2022. Nevertheless, we are contemplating activities earlier than that. In fact, the outcomes and findings arising from the SPRM project will integrate an already existing training package that CRIMEDIM has implemented and delivered since the beginning of the Covid-19 pandemic, in order to train not only health care staff to effectively respond to the current health crisis. Indeed, assuming that "everything is connected with everything", a training that provides only clinical or medical knowledge and competencies, has been revealed insufficient and inadequate. As a matter of fact, it is appropriate that all the professionals involved in crisis management should have a holistic approach of the ongoing emergency which goes beyond their specific field of expertise. Whatever the training is delivered during the acute phase of the emergency or in the context of

preparedness must be more interdisciplinary as possible, so that trainees will understand the complex nature of risk and its capacity to range from sector to sector, reciprocally influencing each other.

Due to the complexity of the identified risks, the vicious cycles, and connectedness of risk sub-systems, human decision-makers cannot foresee the consequences of these system-of-systems. Hence, by conducting workshops involving interdisciplinary experts with complementing experiences applying a method, such as the one supported by *strategyfinder*, assists decision-makers to understand. Finding suitable entries in order to avoid cascading effects would increase chances of success. By directing resources towards where they will have most effect, less time and money is spent on causes not contributing to a solution. For the Center for Teaching and Research in Disaster Medicine and Traumatology (KMC) in Linköping, Sweden, this means better understanding of risks, risk chains, and progress of extremely complex events. KMC is responsible for the regional medical command and control and will benefit from this, but KMC can also use it for teaching as the approach allows for generating scenarios that can be used for realistic future exercises.

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