Before filling out the application form you are requested to read the 'Explanation to the application form' which can be found on the NWO website or via the tab page 'documents' in ISAAC.

General information

1. Main applicant

Main applicant [redacted]

2. Project title:

COMPLEX RESPONSES TO COVID-19 (CoReCo): evolving organisational network configurations during the COVID-19 pandemic, and how they affected measures and outcomes

3. Summary of the proposed research **Word count: 239**

The SARS-CoV-2 virus is causing an unprecedented, highly complex pandemic. In the Netherlands, the response has progressed through various stages, the pre-pandemic phase, the intelligent lockdown, relaxation, and currently a second lockdown. The response can best be understood as the outcome of a complex adaptive system (CAS), in which actors face high levels of complexity, uncertainty, and divergent perspectives on the pandemic and necessary control measures.
The main objective of this study is to determine characteristics of the network configurations during the evolving COVID-19 pandemic, explain changes in these configurations, and identify factors that predict failure and success of dealing with this and future pandemics.
An interdisciplinary team, including practitioners, will work together in 4 substantive work-packages (WP), based on the POLDER approach (https://polder.center) and one coordination-WP. WP 1 and WP 2 analyse the evolving network configurations and practices at the national level and in three safety regions during these stages. Insights will feed into three computational models, developed, tested and calibrated in WP3. WP4 brings together findings from all phases to discuss lessons learned for future pandemics. The study is designed, conducted, and interpreted with key actors in the outbreak control system, which facilitates the utilisation of findings. The outcomes of this project will contribute to our understanding of network configurations and their effects on the response to pandemics as well as our understanding about the impact of interventions seeking to increase the system resilience and performance.

4. Public summary

English:
This study aims to determine characteristics of the response networks during the COVID-19-pandemic in the Netherlands. It identifies factors that predict failure and success of dealing with this and future pandemics. Findings contribute to our understanding of complex decision making and implementation to improve response during this and future pandemics.

Nederlands:
Deze studie heeft tot doel de kenmerken van respons netwerken tijdens de COVID-19-pandemie in Nederland te bepalen. Het identificeert factoren die het falen en succes van de aanpak van pandemieën voorspellen. Bevindingen dragen bij aan ons begrip van complexe besluitvorming en implementatie om deze en toekomstige pandemieën aan te pakken.

5. Discipline code

Main research field	44.10.00	Public administration
Other discipline(s)*	23.40.00	Health sciences

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	16.90.00	Computer science, other
	16.80.00	Computer simulation, virtual reality
	45.90.00	Sociology

* To be filled out if applicable. If needed, you can add rows.

6. Key words

(max 5 key words)

Complex adaptive systems, computational science, network configurations, COVID-19, public health, response infrastructure

Research proposal

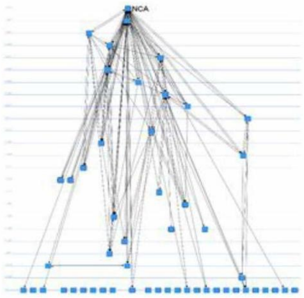
7. Description of the proposed research **Word count: 4995**

Since December 2019, the novel coronavirus SARS-CoV-2 and the related disease, COVID-19, have been causing an unprecedented, highly complex pandemic (Xing & Bing, 2020). COVID-19 usually results in mild, flu-like symptoms but can develop into severe pneumonia, resulting in death. The virus is transmitted through direct contact with an infected person's respiratory droplets or contact with infected surfaces. Asymptomatic carriers can also transmit infection (Khafaie & Rahim, 2020). As of January 19, 2021, almost 100,000,000 Covid-19 infections were recorded worldwide and over 2,000,000 confirmed deaths (WHO, 2020; Worldometer, 2021). When no cure or vaccine for SARS-CoV-2 was available, viral spread was controlled by incentivising hygiene measures, contact tracing, and measures to reduce social contacts, up to complete lockdown (Wilder-Smith, 2020). The necessary containment measures have caused unprecedented economic damages, and enormous societal and psychological costs, worldwide.

The response can best be understood as the outcome of a complex adaptive system (CAS), the combination of many heterogeneous, interacting, and adaptive agents (Angeli and Montefusco, 2020). These aspects characterise both disease spread and containment policies, resulting in non-linear and unpredictable outcomes, highly dependent on context and behaviours, governing organisations and individuals (e.g., Greenhalgh, 2020; Angeli and Montefusco, 2020). Understanding how agents influence each other becomes quintessential (Sternamn, 2002).

The lack of evidence and consensus on its interpretation further contributes to decision-makers' 'bounded rationality'. For example, critical evidence on viral transmission and disease progression was missing at the start, and new mutations create gaps in our understanding. With such uncertainty, behaviours and decisions focus on minimising worst outcomes. The effects of containment policies are unknown and may vary across contexts and time. Dutch Prime Minister Rutte described the situation as "making 100% of the decisions with 50% of the necessary information" (Press conference 12.03.2020). Policymakers and the public assign different values to potential benefits and harms of (non)interventions; generally, they value benefits such as infections averted or reduced morbidity and mortality (e.g. Chorus, 2020). However, saving lives in the short term might sacrifice lives, social order, education, and well-being in the longer term, considering the risks of economic recession and mental health consequences of prolonged lockdown and social distancing. Parameters for decision-making, with unclear information, unpredictable outcomes, and different values applied, are ambiguous and constantly shifting, making the decision-making process inaccurate and short-sighted. The Covid-19 pandemic can clearly be characterised as a 'wicked problem', or 'unstructured problem,' (Rittel and Webber 1973, Head 2008, Hisschemöller and Hoppe, 1995).

Kraaij-Dirkzwager & Wigersma (2020) state that addressing COVID-19 in the Netherlands is done within a complex landscape of many networks that works reasonably well in ordinary times, but may not in times of crisis. Raab et al. (2021) showed, in an organisational-network-scenario study on the outbreak of a New Asian Corona Virus in the Netherlands before the current pandemic, that the complex networks included 43 actors/groups and 28 different containment measures (see Figures 1 and 2).



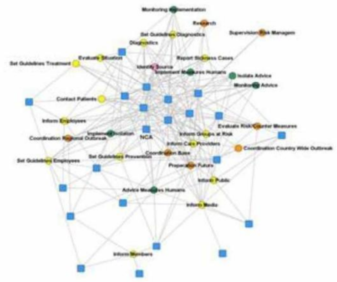


Figure 1- left: Status of actors based on outgoing information ties (Raab et al. 2021)
Figure 2-right:Two-mode network of actors (blue) and their joint involvement in various control measures (Raab et al. 2021)

Actors here encompass health care professionals, public authorities, knowledge institutes and intermediaries. A quick scan shows that the number and type of actors have increased due to the scale and scope in the current crisis, because many non-public health actors are involved in and affected by containment measures. Also, the governance form envisaged before the pandemic has changed. The current (December 2020) COVID-19 crisis structure shows that advice and decisions on measures are taken at the national level, involving stakeholders from science and civil society. Most advice is developed by the OMT, but decisions are ultimately made by the Cabinet. Implementation and regional contextualising is decentralised to the 25 safety regions (coinciding with municipal health regions), established to improve disaster and crisis management. The safety regions vary (e.g. in their demography and level of urbanisation) and are affected differently by the crisis, resulting in different local responses to the outbreak. For example, during the first wave, Groningen advised against travel outside the area, while other regions did not. Before the national advice to wear face masks, Amsterdam and Rotterdam had already advised their use. However, coordination within safety regions is not as straightforward as it may seem. First, they are hampered by the lack of consensus about facts and values, and second, the safety regions are not the only care-network involved in outbreak management. The seven 'GP regions' (each with 23 GP-groups), 11 regions for acute care, and other overlapping networks affect COVID-19 responses.

As described above, the networks are intricate, even without detailing the recursive strategising of actors, decision-makers, implementers, and citizens during the pandemic, resulting in networks that are changing much faster than expected. At this time, we distinguish five distinct phases (see Figure 3): 1st, the pre-pandemic up to intelligent lockdown (January 24 2020 – March 16 2020); 2nd, intelligent lockdown (March 16 2020 – June 1 2020); 3rd, relaxation of measures (June 1 2020 – October 16 2020); 4th, second lockdown (October 16 – unknown); 5th, scale-down (unknown). The 4th phase continues at present; we do not know whether phase 5 will imply scale-down. During these phases, the configurations of actors for decision-making and implementation have changed. Between the first and second phase, the boundaries of the 'public health system,' which traditionally dealt with infectious disease threats, seemed to disappear; 'everyone' and 'all' systems became involved. In the summer relaxation, decision-making was decentralised. During the second lockdown, national organisations again took the lead. In the first phase, mainly existing protocols were followed. Later, apparently a telephone call from the [redacted] at the National Institute of Public Health and the Environment with the Prime Minister on December 11 led to the serious measures in place at the end of 2020. Also, the perspectives of actors have changed. Whereas initially face masks were not widely advised during the 'intelligent' lockdown, they were made mandatory during the 'hard lockdown'. Thus, any attempt to analyse the configurations of decision-making, implementation and effects of interventions should consider the dynamic nature of these configurations.

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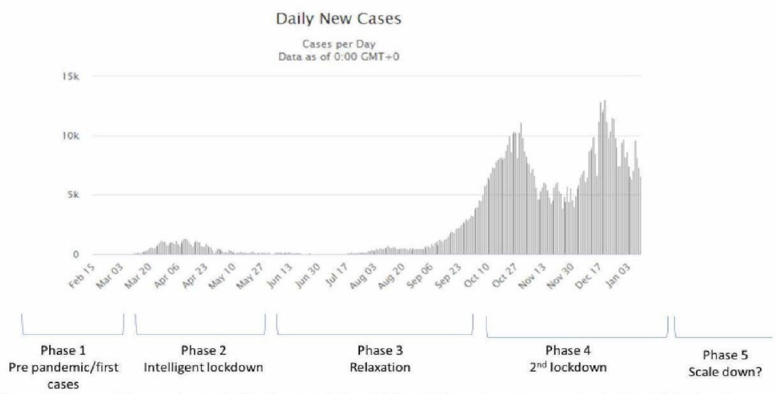

Figure 3: Phases of the pandemic. At this time we distinguish five distinct phases; pre-pandemic up until the intelligent lockdown (January 24 2020 – March 16 2020); the intelligent lockdown (March 16 2020 – June 1 2020); relaxation of the measures (June 1 2020 – October 16 2020); the second lockdown (October 16 – unknown); scale-down (unknown)

While all actors may share a sense of urgency to address the pandemic, it is implausible that the expanding numbers of actors share internalised rules determining behaviour in evolving networks. They come from different system backgrounds, embedding practices governed by a set of (collective) rules (interpretive frames, mental models) and are unlikely to act in conflict with those rules. Normally, this would give stability to systems, making them resist change and stay path-dependent (See Grin & Broerse, 2017 and Geels and Schot, 2010). However, in the new rapidly evolving networks, the actors' different system backgrounds may cause friction. These new networks have no clear rules yet about who has power, or what roles and responsibilities exist. Their functioning depends heavily on the resilience and adaptability of actors in the system and on leadership (van Dijk, 2016).
The above describes network configurations as a number of involved actors with their different ties and often overlapping activities in which decision-making and implementation occur. These network configurations vary over time with regard to these dimensions. These changing network configurations cause 'doublings and lacunes' (Kraaij-Dirkzwager & Wigersma, 2020) that inadvertently affect dealing with the crisis. The current set-up and interlinkages between the central advisory and regulatory bodies and the safety regions and their constituencies may not be functioning optimally. A better understanding of the interactions and feedback loops in this system, and how they influence each measure's effectiveness, can aid in dealing with the current and future pandemics. To understand how these aspects result in function, an internally-consistent description of how the interlinkages generate decisions and actions is needed.
We will co-create, with stakeholders, a modelling framework that can set out this mapping between network performance and outbreak metrics. Besides a holistic understanding, the model will enable i) predicting the effect of network configurations on responses, ii) testing the impact of interventions seeking to increase performance of the system, and iii) test the impact of shocks to evaluate the resilience of the whole structure. Once complete, it will serve as the baseline for a global assessment in which prediction of the impact of the network configurations can be tested across different countries.

Main objective
The main objective of this study is to determine characteristics of the network configurations during the evolving COVID-19 pandemic, explain changes in these configurations, and identify factors that predict failure and success of dealing with this and future pandemics.

Research questions
1) What are the network configurations at central and decentral levels that emerged during the various stages of the crisis?
2) In what way and why did the configurations change (or not)? with a specific focus on the integration of various sub-systems, their adaptability and resilience.
3) What was the effect of these configurations on the implementation of measures taken and on the 'outcomes'?
a4) What lessons can be learned for dealing with future pandemics?.
These questions are further specified in the work packages.

Relevance to the call
Our objective is relevant to the call as we: 1) emphasise how networks configurations evolve during the outbreak, emphasising the relations between central and decentral actors; 2) why they evolve in certain ways and in what way are they hampered by the merging of different systemic ties (resilience and adaptability); 3) what is the effectiveness of these configurations AND interventions on processes and outcomes; 4) by combining insights from computational science and social sciences; 5) the outcomes of this project will contribute to our understanding of network configurations and their effects on the response to pandemics as well as our understanding about the impact of interventions seeking to increase performance of the system.

The approach
An interdisciplinary team, including practitioners, will work together in 5 work-packages (WP), based on the POLicy Decision-support and Evidence-based Reasoning approach (POLDER https://polder.center (figure 4)). The POLDER approach emphasises co-creation with direct stakeholders to build multi-scale models and visualisation tools, to support responsible, evidence-based and effective decision-making. WP 1 and WP 2 analyse the evolving network configurations and practices at the national level and in three safety regions during these stages. Insights will feed into three models, developed, tested, and calibrated in WP3. WP4 brings together findings from all phases to discuss lessons learned for future pandemics. The study is designed, conducted and interpreted with key actors in the outbreak control system, which facilitates the utilisation of findings.

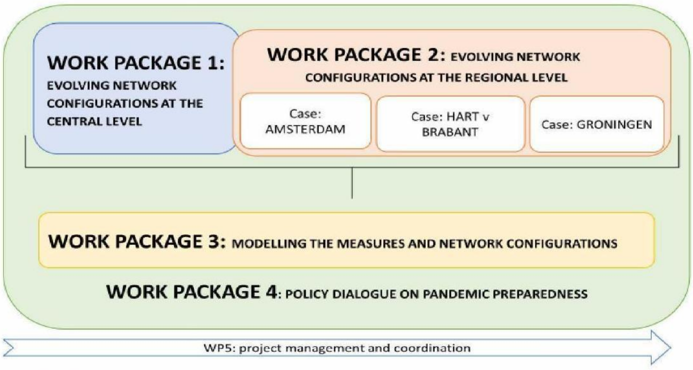

Figure 4: work packages

WORK PACKAGE 1: EVOLVING NETWORK CONFIGURATIONS AT THE *CENTRAL* LEVEL

Lead: Tilburg University

The goal of this work package is to gain insights into network configuartions of the response at the central level. Using a case study approach, we use a realist research to understand the network configuration, why it changed and how implementation within its context was affected.

Questions addressed

Questions addressed are research questions 1, 2 and 3 above, further specified as:

(1) What network structures evolved in the four phases, in responding to the Covid-19 pandemic on the central level?
(2) How did these structures change from one phase to the other over time?
(3) What reasons can be identified for these changes?
(4) How was the response system governed, and how did it change over time?
(5) What were the effects of these network and governance structures in terms of decision processes, decision time, and containment measures?

Concepts

Network structures are conceptualised as actors, i.e. (parts of) organisations, committees and their relationships. We will investigate information exchange, joint involvement in decision-making and implementation of containment measures, as well as collaboration among actors. Governance is the use of institutions, structures of authority and collaboration to allocate resources and coordinate or control activity with regard to the response.

Evolving networks are better understood when we recognise that they exist within complex *and* adaptive, nested and overlapping systems, especially to investigate the highly volatile system now addressing COVID-19. There is a shared sense of urgency; everyone has an interest and a role in dealing with COVID-19. Although actors may share a sense of urgency in the current system, they are unlikely to share the internalised rules that determine behaviour in stable systems. It likely includes actors with different interests, creating new (power) relations and (unexpected) feedback loops (e.g. Loorbach, 2007). Urgency and time pressure mean that actors frequently do not communicate through traditional channels but make use of media appearances or social media posts.

To assess the effect of network configurations, we will investigate process (ease of implementation) output (e.g., tests taken) and outcome indicators (incidence, morbidity/mortality). We acknowledge that it will be difficult to attribute effects directly to network configurations; we, therefore, take a realist perspective.

Methods

The research questions will be addressed using a single case study approach and sequential mixed methods (Yin, 2012). This allows for a realist perspective on what happened, for what reasons, and with what effect, within its temporal and spatial context. We distinguish three steps: exploring, then establishing, then explaining the network configuration.

Exploring: First, we conduct a document to establish in detail the timeline, with which activities are undertaken by whom, with what effect. Simultaneously, a first round of exploratory interviews is conducted with key stakeholders in central decision making structures, including members of the OMT, ministries and the MCCB. We focus on determining network boundaries, specifying which organisations and committees actually participated in the decision process and implementation at central level during the phases of the pandemic. A visualisation of the timeline will structure interviews and enable respondents to link time, actions, actors and outcomes. In this exploratory round, we will further discuss COVID in relation to CAS with respondents.

Initial Documents and data sets for analysis
Official COVID-19 releases of the government
Generic frame for Coronavirus measures (Generiek kader coronamaatregelen, www.rivm.nl)
LCI COVID-19 guideline (lci.rivm.nl)
COVID-19 Data sets (www.rivm.nl)
Technical briefings Dutch Parliament (tweedekamer.nl)

Panel research concerning behavior (Onderzoek naar gedrag en welbevinden in tijden van corona) (www.rivm.nl)

Establishing network configuration: Based on the explorations, a survey with questions for each phase is developed that will be sent to representatives of the relevant organisations and committees. Respondents will be asked to describe their role(s) and potential contributions (unique skills and capabilities) to outbreak control. Second, we will incorporate a list of control activities, based on Raab et al. (2021), asking respondents to indicate in which control activities they were involved. Third, respondents will be asked to indicate per organisation, whether they obtained and/or provided information/advice from and to this organisation. Fourth, we will ask respondents to indicate with which stakeholders they had the most intense collaboration, and their expectations of the activities those stakeholders would undertake. Finally, the respondents will be asked to indicate their perceived level of influence over the outbreak control, and their level of interest in being involved in it. We will then conduct a quantitative network analysis on three types of ties: joint involvement in control activities, providing and receiving information/advice, and collaboration. We will visualise the results in the form of network graphs with software Visone (www.visone.info). To collect network data, one has to identify the parties in a relationship, so the survey cannot be anonymised. We will follow a protocol developed with the Ethical Review Board of the Tilburg School of Social and Behavioral Science based on Borgatti and Molina (2005) and Lemaire and Raab (2019) to ensure maximum transparency towards respondents and to protect their privacy. Only aggregate network structures without node labels are presented in academic publications.
Explaining the configuration and its effects: Based on the insights of the network analysis we will invite key actors for reflection on these finding using; in-depth interviews (N=5/10) and for a(n) (online) workshop (N=15/20). The co-creation workshop comprises two separate sessions, a week apart. We will reflect on the network configuration, emphasising emergent issues from the in-depth interviews. In a second session, we discuss the effects of network and governance structures on decision processes, decision time, and containment measures. In addition, we will ask how they experienced the complexity, uncertainty and value divergence in the different phases, and how the CAS with its networks was or was not able to process and cope with those. The second workshop is also expected to establish properties for the modelling in WP3.

Output, knowledge utilisation and linkages to other WPs

- The academic output of this WP is the analysis of the involved actor set, the network structures based on different types of relations, how the response system was governed, how that changed through the different pandemic phases, and the respective effects on outputs. In particular, linking the network analysis with the rapid temporal changes is novel.
- Establishing properties of agents and their relationships, such as evolving goals, used metrics of success, and information flows, contributes to modelling in WP3.
- The workshops also function as knowledge utilisation/translation activities, with the actors within our sphere of control. A policy brief is written for further dissemination.

WORK PACKAGE 2: EVOLVING NETWORK CONFIGURATIONS AT THE *REGIONAL* LEVEL

Lead: Vrije Universiteit van Amsterdam

The goal is to gain insights in network structures and governance of the response at regional/GGD level and interactions with national level. This WP follows a similar structure to WP1. The GGD regions under investigation are GGD-Groningen, GGD-Amsterdam and GGD-Hart voor Brabant.

Questions addressed

This WP addresses study questions 1, 2 and 3 above, further specified as:

- What network structures evolved at the regional/GGD level through the four pandemic phases, in response to the Covid-19 pandemic?
- What structures evolved between the central/national and the regional/GGD levels?
- How did these structures change from one phase to another over time?

- What reasons can be identified for these changes?
- How was the response system governed at regional, and from national to regional, level? How did that change over time?
- How did these network and governance structures influence decision processes, decision time, and containment measures?

Concepts & Methods
This WP is structured as a multiple case study (Yin, 2012), but is otherwise similar to WP1. The selected cases were identified as *rich cases* to provide diversity. At the start of the pandemic, Hart voor Brabant had the highest incidence but limited comparative insights to establish a network or select specific control measures. Amsterdam represents an area with high incidence in the relaxation phase and was pro-active in initiating regional control measures (e.g., face-mask policies). Groningen was chosen for its relatively low incidence. Together, they represent different demographic and cultural areas in the Netherlands.
Exploring network configurations, establishing network configurations, and explaining them will use an approach similar to that described above, including data collection and network analysis of the regional actors and their interactions with the central level, and workshops. Respondents will include different key actors within each GGD's safety region.

Output, knowledge utilisation and linkages to other WPs

- The academic outputs of this WP are: analysis of the actor sets, network structures based on different types of relations, how the response system was governed, how that changed through different pandemic phases, and effects on outputs from a comparative perspective.
- Establishing properties of agents and their relations/loop structures for modelling in WP3.
- The workshops also function as knowledge translation/utilisation activity, with the actors within our sphere of control. Policy briefs are disseminated within each safety region.

WORK PACKAGE 3: MODELLING THE MEASURES AND NETWORK CONFIGURATIONS
Lead: Universiteit van Amsterdam
The goal of this WP is to derive understanding of the impacts of the network configurations. We will design an applied model to i) test the role of interventions in improving the efficacy of governance structures and ii) measure the resilience of the current and alternative systems to different types of shocks, to assess their resilience. We will split the modelling into three modular sections, which will interact with one another. We list them by importance in our study: (a) decision making networks; (b) social dynamics; (c) disease dynamics. Each will take the others as externally given (see data sources below).
Questions addressed
Questions addressed in this WP are 3 and 4 as written above. These are further specified in this WP into:

- What interaction structures are present (namely agents' goals and mental models and procedural delays) and how do they contribute to the overall dynamics of the coupled management-disease system?
- Which structures contribute the most for the impact of decisions in metrics of the outbreak (including inertia, delays, and unanticipated consequences)?
- What structures are more resilient to shocks (e.g., other crises, disappearance of agents, misinformation)?

Concepts
We will make use of causal loop structures to be built directly from WP1 and WP2 (Hovmand, 2014). These will be turned into different types of models. For the network structures, we will use agent-based models on a complex network. For aggregated properties regarding rapidly evolving socioeconomic and the outbreak statistics, we will use systems dynamics focusing on a metapopulation approach to describe the different regions.

Methods
Each of the three models will be tackled in two parallel and complementary approaches: *i*) the fundaments of complexity approach and *ii*) the POLDER (https://polder.center) approach. Model (a) decision-making network will use a networked agent-based model to capture information flows and decisions taken on the network governance of the pandemics. Model (b) social dynamics will take behavioural aspects of the population which depend on social contagion. We will use global data sources to test a range of internal mechanisms that explain the observed behaviour (see data sources below). Since these dynamics are highly unexplored, the main uncertainty comes from the underlying process and structures. Thus, we will use a family of empirical models and social structures to explore different social responses which are still compatible with the data (Vasconcelos,et al. 2019). This variation in behavioural response will be leveraged to test the resilience of the network structures to different behavioural responses. Model (c) will focus on disease-spread dynamics. We will start with typical models of disease contagion which focus on translating the disease propagation on the information available to the managers.
*Fundaments of complexity approach:*Here, we look for insights and systematisation of complexity concepts of controlling contagion processes. It encompasses the creation of minimal conceptual models that rely on stylised facts. It aims to derive simple, tractable results, generalisable beyond the particularities of this pandemic while drawing heavily from it. The POLDER approach below covers the details. For model (a) we will start with the traditional optimiser at a prescribed timeframe (e.g., minimising yearly mortality, hospital admission, or estimated economic costs). Given the limited information at the beginning of any pandemic, important trade-offs (in the form of exploration-exploitation dilemmas) are likely to arise and be addressed using and adapting the multi-armed bandit frameworks. We will consider the connectivity between the different regions (and their managers) to be homogeneous and then will move into more realistic networks with small-world effects and scale-free properties, with a hierarchical layer. As WP1 and WP2 provide further insights into the structure of the governing network, the properties of those networks can be assessed. For model (b) we will consider purely rational individuals with partial information, e.g. on the risk of infection, so we can make use of game-theoretical tools to determine behavioural changes, e.g. on mask-wearing behaviour or participation in indoor activities. We expect powerful insights from this analysis, like the segregation of behaviours according to risk preferences with important feedbacks with the contagion process itself. Extensions include the role of bounded rationality, namely social norms (and imitation). For model (c), we will begin with an extended SIR model; later we will extend this for any additional compartments in which interventions can be made and among region connectivity (thought of at the safety-region level or GGD regions). Each of these will be made more realistic within the POLDER approach.
POLDER approach: In workshops with stakeholders and/or expert elicitation via WP1 and WP2, the most important factors and feedbacks are identified, interventions designed, and interpretations of model outcomes evaluated. While the Fundaments of Complexity focuses on finding properties of agents' and systems' responses, the POLDER approach focused on detailing properties of the specific regions studied.
POLDER is built on sequential steps. Step 1 uses a co-creation of scientists and stakeholders to identify, rank, and balance the most important aspects, actors, and processes of the health-care system affected by the COVID-19 pandemic, with special focus on external drivers and internal positive and negative feedbacks, derived from WP1 and WP2. Step 2 is the development of a digital twin system, an agent-based multiplex network that mimics the dynamics of internal relations in the context of external drivers and the implementation in a computer simulation model. The models will be built in blocks: a model for the network of governance actors which acts on metrics of the outbreak interacting with a model of social behaviour and the propagation of disease. This is no longer analytically tractable, but it should be able to recover the results of analytically tractable models under the same set of assumptions. This forces a thorough description of the assumption of analytically tractable models. Step 3 and 4 will be largely covered in WP 4, with this package focusing on computational implementation. Step 3 is the interpretation and evaluation of model results together with stakeholders. This will (a) initiate extra iterations in the multiplex network (i.e., revisiting Step 2), and (b) design interventions for improving specific goals of the stakeholders. Step 4 uses computer simulations

to iteratively predict the efficacy of interventions, evaluate these, design new interventions, and test the overall resilience to external shocks. Step 4 cares particularly about endogenising and identifying externalities of interventions to avoid "unintended consequences". Below an initial set of publicly available datasets that will be used.

What	Source	Detail	Link
Mask wearing rate over time	YouGov & Imperial College behavior tracker	Percentage of individuals wearing a mask when they go out, bi-weekly from March to December, per country	https://github.com/YouGov-Data/covid-19-tracker
Perceived risk over time	Yougov + Armin Falk Global Preferences Survey	A country-level estimate of the perceived risk of COVID-19 infections	https://yougov.co.uk/covid-19; https://www.briq-institute.org/global-preferences/home
Other Global Preferences	Global Preferences Survey (briq-institute.org)	A dataset on risk and time preferences, positive and negative reciprocity, altruism, and trust.	https://www.briq-institute.org/global-preferences/home

Table 1: social behaviour

What	Source	Detail	Link
COVID-19 Government Response	CoronaNet project	COVID-19 Government Response Event Dataset (CoronaNet v.1.0)	https://www.coronanet-project.org https://www.nature.com/articles/s41562-020-0909-7
Public health and social measures applied	WHO PHSMs dataset	A global database of public health and social measures applied during the COVID-19 pandemic	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/phsm
Policy timelines for a range of key PHSM	HIT	The Health Intervention Tracking is a global database that catalogues the implementation and relaxation of COVID-19 related public health and social measures (PHSM)	https://akuko.io/post/covid-intervention-tracking

Table 2: Governance.

What	Source	Detail	Link
Conformity	Personality and Social Psychology Bulletin, 2018, 45(6):014616721880283	A country-level estimate of the tendency for conformity and sanctioning of social norm or rule violations	https://www-jstor-org.ezproxy.princeton.edu/stable/27977953?pq-origsite=summon&seq=4#metadata_info_tab_contents
Prosociality score	Journal of Personality and Social Psychology, 2013, Vol. 104, No. 4, 635– 652	Cross-Cultural scores on prosocial spending and well-Being	https://www.apa.org/pubs/journals/releases/psp-104-4-635.pdf

Table 3: Other data

Output, knowledge utilisation and linkages to other WPs

- POLDER is a concept for an integrated systems approach to support decision making in realistic complex adaptive systems. This WP looks to consolidate and implement the knowledge derived in WP1 and WP2 and to, iteratively with WP4, develop a computational model.
- The framework is developed so that its output can be used as a tool for knowledge communication (effects of decisions) and knowledge education (decision making in a complex world).

WORK PACKAGE 4: POLICY DIALOGUE ON PANDEMIC PREPAREDNESS -*Lead: Vrije Universiteit van Amsterdam*
The goal of this WP, organised by all members, is to integrate all findings and identify lessons learned for future pandemics, making it critical for further knowledge utilisation.

Question addressed: What lessons can be learned for dealing with future pandemics?

Concepts: This WP builds upon all prior conceptualisations.

Methods/approach

Together with members of participating GGDs and the RIVM, the research team develops a working document with lessons learned on success and failure factors of network configurations during the COVID-19 response, including various scenarios for future outbreaks. A workshop (N=20/30) is organised with key actors with decision-making power, to simulate scenarios and possible network configurations that explicate roles and responsibilities of the network actors. In co-creation sessions, 'preferred' network configurations are discussed in relation to severity of potential outbreaks, explicating the relations between central and regional actors.

Output and linkages to other WPs

- The outcomes of this, integrated with others will be described in a policy brief, an animated video and/or podcast
- A final document on 'preferred network configurations dealing with future pandemics', including the tools, is developed.

WORK PACKAGE 5: PROJECT MANAGEMENT -Lead: Vrije Universiteit van Amsterdam
WP5 is created to synchronise activities in this transdisciplinary project. The team has compatible academic and practical backgrounds. Highly relevant is the management of the integration of academic and societal insights from public health partners participating in this call: the RIVM and three GGD regions. Partners joined in developing this proposal and will contribute throughout the project, from design to analysing and utilising results. Monthly meetings with all consortium members ensure alignment of activities. A supervisory board of experts in public health, systems thinking, communication, and public administration advises on progress. Four half-yearly meetings are organised.
Specifically in this WP, we provide the overall scientific direction and drive project progress; set up a project management structure to ensure efficient operational management according to work plans; set up the advisory committee; provide resources, procedures and tools for ensuring that all results are delivered on time; enabling appropriate communication and work dynamics to help drive the whole Consortium as a team towards successful completion. A more detailed management plan is developed.

8. Planning of the proposed research

Envisaged start date: ***October 1st 2021***
Envisaged end date: ***September 30st 2023***

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9. Work plan of the proposed research **Word count: 350**

Under 'approach' and in 'WP5' we have detailed the work plan of our transdisciplinary team. Note that master-students of all universities will also participate in data-collection and analysis. Underneath we further specify activities in a GANT-CHart. Msc. WP1 (lead TU) will start prior to all other WPS, as it provides crucial information on methods and content for the case studies in WP2 (VUA). Also the case studies are phased, to allow for learning form methods. The foundational work to develop the model can start quickly, but the actual modelling depends on insights from the empirical case studies and is therefore organised when information becomes available. WP4 brings together all analysis at the end. To ensure cohesion within the project we organize monthly meetings and the Post-Docs are involved in all WPs. THe post-doc at VU and TU will lead WP 1 and 2, but the UVA post-docs (i.5fte, two post-docs) are involved in these WPs to ensure that they data is collected in a way it can feed back into the modelling. Vice versa the VU/TU postdocs are involved in the modelling to align data collection and provide hypothesis. The 4th WP will be a shared action by all post-docs supervised.

Gant chart of proposed activities CoReCo			Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
WP 1	Exploring configurations		■	■						
	Establishing configurations				■	■				
	Explaining configurations						■			
WP 2	GGD Hart v Brabant	Exploring		■						
		Establishing			■	■				
		Explaining					■			
	GGD Amsterdam	Exploring			■					
		Establishing				■	■			
		Explaining						■		
	GGD Groningen	Exploring			■					
		Establishing				■	■			
		Explaining						■		
WP 3	Model (a) decision making networks			■	■	■	■	■	■	■
	Model (b) social dynamics		■	■	■	■	■	■		
	Model (c) disease dynamics		■	■	■	■	■			
WP 4	Dialogue on lessons learned/scenarios								■	■
	Developing guidelines and tools on lessons learned								■	■
	final workshop/symposium									■
WP 5	monthly project team meetings on content and process		■	■	■	■	■	■	■	■
	Setting up data management and sharing plan		■							
	Advisory board committee			■		■		■		■
	Knowledge utilisation and communication		■	■	■	■	■	■	■	■

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10. Literature references

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- Novel, C. P. E. R. E. (2020). The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China. *Zhonghua liu xing bing xue za zhi= Zhonghua liuxingbingxue zazhi, 41*(2), 145.
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- Wilder-Smith, A., & Freedman, D. O. (2020). Isolation, quarantine, social distancing and community containment: pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. *Journal of travel medicine*, 27(2), taaa020.
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11. Data management

1. Will data be collected or generated that are suitable for reuse?

Yes: *This project will build on a combination of existing data and data from our interviews and workshops. All data will be anonymized before storing, and stored original data will be made available for re-use, in accordance with the open science policy and FAIR principles supported by all academic partners. This is the case for interviews. The relational network data will be made available in aggregate form and completely anonymised. The model and simulation results will be made available anonymised. Workshop data are context dependent to the extent that they are not relevant for re-use outside workshop settings. Moreover, due to a smaller number of participants, anonymizing has less effect. As a result, only processed data from workshops will be made available. During the project data will be stored at surfdrive. After the project data generated during the project will be stored in the Data Archiving and Networking Services of KNAW (dans.knaw.nl).*

2. Where will the data be stored during the research?

During the project data will be stored on surfdrive. All participating university partners have access to surfdrive.

3. After the project has been completed, how will the data be stored for the long-term and made available for the use by third parties? To whom will the data be accessible?

As stipulated above data will be made available anonymised, and at times in aggravated form. Apart from workshop data that is context dependent and hard to anonymise. After the project data generated during the project will be stored and made available in the Data Archiving and Networking Services of KNAW (dans.knaw.nl).Private data will be stored at Darkstor.

4. Which facilities (ICT, (secure) archive, refrigerators or legal expertise) do you expect will be needed for the storage of data during the research and after the research? Are these available?*

The aforementioned repositories are sufficient for storage and available.

*ICT facilities for data storage are considered to be resources such as data storage capacity, bandwidth for data transport and calculating power for data processing.

Applicant(s) (optional: and other members of the team)

12. Main applicant

Name, title(s):	[redacted], [redacted]
PhD date:	[redacted]
Position:	[redacted]
End date contract**:	permanent
University:	Vrije Universiteit van Amsterdam
Department/Section:	Athena Institute
Postal Address:	De Boelelaan 1085
Zip code/City:	1081HV Amsterdam
Email:	[redacted]@vu.nl
Phone:	[redacted]
Website:	https://science.vu.nl/en/research/athena-institute/index.aspx

13. Co-applicant(s)* (optional)

Name, title(s):	[redacted]
PhD date:	[redacted]

Position:	[redacted]
End date contract**:	permanent
University:	Tilburg University
Department/Section:	Department of Organization Studies/School of Social and Behavioral Sciences
Postal Address:	Tilburg
Zip code/City:	5000LE
Email	[redacted]@uvt.nl
Phone:	[redacted]
Website:	https://research.tilburguniversity.edu/en/persons/j%C3%B6[redacted]

Name, title(s):	[redacted]
PhD date:	[redacted]
Position:	[redacted]
End date contract**:	permanent
University:	Tilburg University
Department/Section:	Department of Public Governance/School of Economics and Management
Postal Address:	Tilburg
Zip code/City:	5000LE
Email	[redacted]@tilburguniversity.edu
Phone:	[redacted]
Website:	[redacted] — Tilburg University Research Portal

Name, title(s):	[redacted]
PhD date:	[redacted]
Position:	[redacted]
End date contract**:	permanent
University:	University of Amsterdam
Department/Section:	Informatics Institute
Postal Address:	Science Park 904
Zip code/City:	1098XH Amsterdam
Email	[redacted]@uva.nl
Phone:	[redacted]
Website:	https://www.uva.nl/en/profile/k/r/v.[redacted].html

Name, title(s):	[redacted]
PhD date:	[redacted]
Position:	[redacted]
End date contract**:	Dec-2026
University:	University of Amsterdam
Department/Section:	Informatics Institute
Postal Address:	Science Park 904
Zip code/City:	1098XH Amsterdam

Email	[redacted]@uva.nl
Phone:	[redacted]
Website:	[redacted].github.io

Name, title(s):	[redacted]
PhD date:	[redacted]
Position:	[redacted]
End date contract**:	permanent
University:	Vrije **Universiteit** van Amsterdam
Department/Section:	Athena Institute
Postal Address:	De Boelelaan 1085
Zip code/City:	1081HV Amsterdam
Email:	[redacted]@vu.nl
Phone:	[redacted]
Website:	https://science.vu.nl/en/research/athena-institute/index.aspx

14. Quality of the applicant(s)

Main applicant: [redacted] **Word count: 497**

[redacted]

5 key publications

Broerse, J.E.W. & Grin, J. (eds.) (2017) *Toward Sustainable Transitions in Healthcare Systems*. New York: Routledge. (peer-reviewed)

Popa, E, Petit-Steeghs, Vi, de Graaff, B, **Broerse, J.E.W**. (2021) Stakeholder interaction in risk governance: lessons from six cases in the Netherlands, journal of risk research (revisions)

Schölvinck, A.M. Pittens, C.A.C.M. & **Broerse, J.E.W.** (2020) Patient involvement in agenda-setting processes in health research policy: A boundary work perspective, *Science and Public Policy*, scaa001.

Kok, K.P.W.; den Boer, A.C.L.; Cesuroglu, T.; van der Meij, M.G.; de Wildt-Liesveld, R.; Regeer, B.J.; **Broerse,** [redacted]**.** (2019) Transforming Research and Innovation for Sustainable Food Systems — A Coupled-Systems Perspective. *Sustainability*, **11**(24), 7176.

Middel, C.N.H., Schuitmaker-Warnaar, T.J., Mackenbach, J.D. & **Broerse, J.E.W.** (2019) Systematic review: a systems innovation perspective on barriers and facilitators for the implementation of healthy food-store interventions. *Int J Behav Nutr Phys Act* **16,** 108.

Co-applicant: [redacted] **Word count: 500**

[redacted]

Key publications with regard to the proposal:

Raab, J., Kenis, P., Kraaij – Dirkzwager, M., & Timen, A. (2021). Ex ante knowledge for infectious disease outbreaks: Introducing the organizational network governance approach. In J. Glückler, G. Herrigel, & M. Handke (Eds.), Knowledge for Governance (Vol. 15, pp. 319).

Kenis, P., Raab, J. 2020. Back to the Future: Using Organization Design Theory for Effective Organizational Networks. Perspectives on Public Management and Governance: 109-123.

Maessen, J.H.J, Raab, J., Haverkate, M., Smollich, M., ter Waarbeek, H.L.G., Eilers. R., Timen, A. 2019. How prepared are we for cross-border outbreaks? An exploratory analysis of cross-border response networks for outbreaks of multidrug resistant microorganisms in the Netherlands and Germany. PlosOne.

de Vries, M., Kenis, P., [redacted]., Ruitenberg, E. J., Raab, J., [redacted]. 2019. Collaborative emergency preparedness and response to cross-institutional outbreaks of multidrug-resistant organisms: a scenario-based approach in two regions of the Netherlands, BMC Public Health.

Berthod, O. Grothe-Hammer, [redacted], G., Raab, J., Sydow, J. 2017. From High-Reliability Organizations to High-Reliability Networks: The Dynamics of Network Governance in the Face of Emergency, Journal of Public Administration Research and Theory, 27 (2): 352–371.

Raab, J., Mannak, R. and B. Cambré. 2015. Combining Structure, Governance and Context: A Configurational Approach to Network Effectiveness, Journal of Public Administration Research and Theory, 25: 479-511.

Co-applicant: [redacted] **Word count: 464**

[redacted]

Key publications with regard to the proposal:

Raab, J., Kenis, P., Kraaij – Dirkzwager, M., & Timen, A. (2021). Ex ante knowledge for infectious disease outbreaks: Introducing the organizational network governance approach. In J. Glückler, G. Herrigel, & M. Handke (Eds.), Knowledge for Governance (Vol. 15, pp. 319).

Kenis, P., Raab, J. (2020). Back to the Future: Using Organization Design Theory for Effective Organizational Networks. Perspectives on Public Management and Governance: 109-123.

Kenis, P., Schol, L. G., Kraaij-Dirkzwager, M. M., & Timen, A. (2019). Appropriate governance responses to infectious disease threats: developing working hypotheses. *Risk, Hazards & Crisis in Public Policy*, *10*(3), 275-293.

Nowell, B. L., & Kenis, P. (2019). Purpose-oriented networks: The architecture of complexity. Perspectives on Public Management and Governance, 2(3), 169-173.
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van den Oord, S., Lemaire, R., Kenis, P., & Cambré, B. (2017). The Governance, Structure and Management Processes of an Emergent Goal-directed Organizational Network: an Evaluation of a Configurational Framework of Goal-directed Networks. International Journal of Integrated Care, 17(5).

Co-applicant: [redacted] **Word count: 453**

[redacted]

Selected publications:

Melnikov VR, Krzhizhanovskaya VV, Lees MH, Sloot PMA. The impact of pace of life on pedestrian heat stress: A computational modelling approach. Environmental Research. 2020;186: 109397

Presbitero A, Mancini E, Brands R, Krzhizhanovskaya V, Sloot P. Supplemented alkaline phosphatase supports the immune response in patients undergoing cardiac surgery: Clinical and computational evidence. Frontiers in immunology. Frontiers; 2018;9: 2342.

Metsker O, Magoev K, Yakovlev A, et al. Identification of risk factors for patients with diabetes: diabetic polyneuropathy case study. BMC Medical Informatics and Decision Making. 2020;20: 201

Presbitero A, Quax R, Krzhizhanovskaya VV, Sloot PMA. Detecting Critical Transitions in the Human Innate Immune System Post-cardiac Surgery. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). 2020. pp. 371–384

Fu X, Presbitero A, Kovalchuk SV, Krzhizhanovsk
aya VV. Coupling Game Theory and Discrete-Event Simulation for Model-Based Ambulance Dispatching. Procedia Computer Science. Elsevier; 2018;136: 398–407.

Melnikov V, Krzhizhanovskaya VV, Sloot PMA. Models of Pedestrian Adaptive Behaviour in Hot Outdoor Public Spaces. Procedia Computer Science. 2017;108: 185–194

Melnikov V, Krzhizhanovskaya VV, Lees MH, Sloot PMA. System dynamics of human body thermal regulation in outdoor environments. Building and Environment. 2018;143: 760–769

Fisher WD, Camp TK, Krzhizhanovskaya VV. Anomaly detection in earth dam and levee passive seismic data using support vector machines and automatic feature selection. Journal of Computational Science. 2017;20: 143–153

Krzhizhanovskaya VV, Shirshov GS, Melnikova NB, Belleman RG, Rusadi FI, Broekhuijsen BJ, et al. Flood early warning system: design, implementation and computational modules. Procedia Computer Science. 2011;4: 106–115

Co-applicant: [redacted] 5.1.2e **Word count: 359**

[redacted] 5.1.2e

Key publications with regard to the proposal:

W Barfuss, JF Donges, VV Vasconcelos, J Kurths, SA Levin. 2020. Caring for the future can turn tragedy into comedy for long-term collective action under risk of collapse. Proceedings of the National Academy of Sciences 117 (23), 12915-12922

VV Vasconcelos, PM Hannam, SA Levin, JM Pacheco. 2020. Coalition-structured governance improves cooperation to provide public goods. Scientific Reports 10 (1), 1-10

VV Vasconcelos, SA Levin, FL Pinheiro. 2019. Consensus and polarization in competing complex contagion processes. Journal of the Royal Society Interface 16 (155), 20190196

PM Hannam, VV Vasconcelos, SA Levin, JM Pacheco. 2015. Incomplete cooperation and co-benefits: deepening climate cooperation with a proliferation of small agreements. Climatic Change, 1-15

VV Vasconcelos, FC Santos, JM Pacheco, SA Levin. 2014. Climate policies under wealth inequality. Proceedings of the National Academy of Sciences 111 (6), 2212-2216

VV Vasconcelos, FC Santos, JM Pacheco. 2013. A bottom-up institutional approach to cooperative governance of risky commons. Nature Climate Change 3 (9), 797-801

Co-applicant: [redacted] **Word count: 459**

[redacted]

Key publications with regard to the proposal:

Essink, D. R., Ratsavong, K., Bally, E., Fraser, J., Xaypadith, S., Vonglokham, M., ... & Kounnavong, S. (2020). Developing a national health research agenda for Lao PDR: prioritising the research needs of stakeholders. Global health action, 13(sup2), 1777000.

Essink, D. R. (2012). Sustainable health systems: the role of change agents in health system innovation.

Clements, D., & Essink, D. (2018). Contextualizing evidence in Canadian healthcare. In Toward Sustainable Transitions in Healthcare Systems (pp. 208-234). Routledge.

Broerse, J. E. W., Essink, D. R., & Bunders-Aelen, J. G. F. (2010). Reflections on persistent problems and strategies for health system innovation. In Transitions in Health Systems: Dealing with persistent problems (pp. 209-229). VU University Press.

Chaleunvong, K., Phoummalaysith, B., Phonvixay, B., Sychareun, V., Durham, J., & Essink, D. R. (2020). Factors affecting knowledge of National Health Insurance Policy among out-patients in Lao PDR: an exit interview study. Global Health Action, 13(sup2), 1791414.

15. Other members of the team* (optional)

Private partners, research partners (from other research institutes that are not eligible for NWO funding), etc.

Name, title(s):	professor dr. [redacted]
Organization/company	RIVM / Vrije Universiteit van Amsterdam
Discipline/position:	[redacted]
Country:	Netherlands
Postal Address:	Postbus 1
Zip code/City:	3720 BA Bilthoven
Email:	[redacted]@rivm.nl / [redacted]@vu.nl
Phone:	[redacted]
Website organisation/company:	www.rivm.nl
Personal website	https://research.vu.nl/en/persons[redacted]

Name, title(s):	[redacted], MD, PhD
Organization/company	GGD Amsterdam
Discipline/position:	Head infectious disease control
Country:	Netherlands
Postal Address:	Nieuwe Achtergracht 100
Zip code/City:	1018 WT Amsterdam
Email:	[redacted]ggdamsterdam.nl
Phone:	[redacted]
Website organisation/company:	www.GGD.Amsterdam.nl
Personal website	https://www.linkedin.com/in/[redacted]

Name, title(s):	[redacted]
Organization/company	GGD Hart voor Brabant
Discipline/position:	[redacted]
Country:	Netherlands
Postal Address:	Postbus 3024
Zip code/City:	5003 DA Tilburg
Email:	[redacted]ggdhvb.nl
Phone:	[redacted]
Website organisation/company:	GGD Hart voor Brabant (ggdhvb.nl)
Personal website	https://www.linkedin.com/in[redacted]?originalSubdomain=nl

Name, title(s):	[redacted]
Organization/company	GGD Groningen

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Discipline/position:	[redacted]
Country:	Netherlands
Postal Address:	Hanzeplein 120
Zip code/City:	9700 AN Groningen
Email:	[redacted]@ggd.groningen.nl
Phone:	[redacted]
Website organisation/company:	www.GGD.Groningen.nl
Personal website	https://www.linkedin.com/in/[redacted]

16. Supervision

Please indicate who will act as supervisor(s) of the requested post doc(s).

Requested position	**Supervisor(s)**
Postdoc Tilburg	[redacted]
Postdoc VU	
Postdoc UVA 1	

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Financial details

17. Project budget

Please upload the project budget as a separate Excel file in ISAAC. Please read the ***explanation to the application form*** *carefully before filling out the Excel form.*

18. Justification of the budget **Word count: 461**

Personnel costs : To ensure that the ambitious empirical and analytical goals of the project are met, we have budgeted for in total 3.5 fte Postdocs and 0,2 leave time to ensure project and knowledge integration. Other supervision is financed elsewise. The projects requires a diversity of disciplinary knowledge. 2 fte Postdocs work primarily on WP 1, 2 and 4 and should have an understanding of: public health, public administration, systems thinking, network analysis, qualitative analysis and survey research. 1.5 fte postdoc will focus on the modelling in WP3, but are also involved in WP 1,2, and 4. Developing each of the three models is estimated at .5fte for two years. These postdocs should have sufficient knowledge of agent based and systems modelling. Research leave is budgeted for a transdisciplinary researcher with a background in systems thinking to support integration of findings and be responsible for the project. Supervision of postdocs is done by the (co-)applicants and other members of the team. Total budget for personnel: [redacted] euro (including bench fees).

Material costs:

<u>Project related goods</u>: the three models that we make require access to data sets. Although we make use of many existing data sources: see table 1, 2 and 3, we have budgeted [redacted] for acquiring or using additional data collections (e.g. from Central Office for Statistics/media data).

Travel and accommodation costs for the personal positions; travel and accommodation costs + conference attendance: to share and acquire insights, each postdoc fte is expected to visit at least one national and one international conference. (estimated total costs [redacted]

<u>Fieldwork</u>: Fieldwork is mostly related to organising the interviews (expected at more than 120), the surveys, workshops are budgeted below. We reserve money for traveling and mainly support with transcription of data from interviews and workshops – student assistants, and editing (estimated costs [redacted].

<u>Implementation costs</u>: In total 10 workshops are planned including a large final symposium. For each workshop we reserve [redacted] euro. Amounting to [redacted] euro.

We will only publish open access. We expect that for 4 to 5 articles we have to pay publication fees. For that, we reserve in total [redacted] euros.

Knowledge utilisation: Part of the knowledge utilisation is covered by the workshops planned in WP1 and 2. For the knowledge utilization budget we dedicate [redacted] euro to support utilisation activities for the workshops in WP4. We further budget [redacted] euro for developing dedicated materials: maintain a website, develop guidelines for infectious disease responses and its tools, policy brief, (video) visualisations and/or podcasts for broader use of the outcomes of the study. We also budget [redacted] euro for knowledge exchange activities for senior staff.

Internationalisation: We budget [redacted] euro for travel of 3/4 international experts for the mid-term advisory board meeting. Travel expenses and a three day stay.

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20. Other grant applications for this project or idea

☐ Not applicable

☐ Yes

Statements and signature

21. Statements by the PI

By submitting this form, I endorse the code of conduct for laboratory animals and the code of conduct for biosecurity/possibility for dual use of the expected results and will act accordingly if applicable.

Please tick the boxes where applicable.

☐ By submitting this form through ISAAC, I declare that I have completed this form truthfully and I declare that I have informed the correct official(s) of my employing institute of this submission (e.g. the scientific director or dean).

☐ I hereby declare that the obligatory guarantee letters for each applicant whose contract term is shorter than the lead time of the envisaged research (if applicable) have been uploaded separately in ISAAC.

☐ By submitting this form I declare that I satisfy the nationally and internationally accepted standards for scientific conduct as stated in the Netherlands Code of Conduct for Scientific Practice 2018 (Association of Universities in the Netherlands).

Name: [redacted]
Place: Amsterdam
Date: 26-1-2021

Before you submit the full proposal application in ISAAC you will be asked to sign the application electronically.

<u>Deadline for submitting the application: January 26, 2021, 14.00 hours CET</u>