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Appropriate Governance Responses to Infectious Disease Threats: Developing Working Hypotheses

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Infectious diseases remain a threat to public health in today's interconnected world. There is an ongoing debate on how responses to threats of infectious diseases can best be coordinated, and the field remains nascent in understanding which specific structural governance arrangement will perform best. The present paper contributes to this discussion by demonstrating that it is possible to develop working hypotheses specifying the relationship between the type of infectious disease crisis and type of response to the crisis. For type of crises and type of response mechanisms there is still a lack of research, but the hypothesis combining these two provide a perspective for a future research and action agenda. It certainly prevents us from choosing between schism or hypes when it comes to crisis response. It provides instruments to realize that no single type of response is the most effective and that not all responses are equally effective in a concrete case.

KEY WORDS: Network Governance, Response, Outbreak Management, Typology of Threats, Infectious Disease

应对传染性疾病威胁的适宜治理响应: 提出可行假设

传染性疾病在当今全球互联互通的情况下仍然是公共卫生的一大威胁。越来越多的辩论有关于传染性疾病威胁响应一事如何能受到最好的协调，同时，该领域对"具体哪一种结构性治理安排的表现最佳"的认识还处于初期阶段。本文通过证明，有可能存在可行的假设以确定传染性疾病危机类型和危机响应类型之间的关系，从而促进了这方面的探讨。就危机类型和响应机制类型而言，还缺乏足够研究，然而将这二者合并研究的假设却能为今后研究和行动议程提供一个视角。该假设能防止在有关灾害响应的分歧或言过其实的宣传之间做出选择。该假设提供相关工具，以证明没有一个响应类型是最有效的，也并不是所有响应类型都在一个具体案例中具备相同的有效性。

关键词: 网络治理, 应对, 疫情管理, 威胁类型, 传染病

Respuestas De Gobierno Apropiadas A Las Amenazas De Enfermedades Infecciosas: Desarrollo De Hipótesis De Trabajo

Las enfermedades infecciosas siguen siendo una amenaza para la salud pública en el mundo interconectado de hoy. Existe un debate en curso sobre cómo se pueden coordinar mejor las respuestas a

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las amenazas de enfermedades infecciosas, y el campo sigue sigue estando en su infancia en términos de su comprención de qué sistema de gobernanza estructural específico funcionará mejor. El presente documento contribuye a esta discusión al demostrar que es posible desarrollar hipótesis de trabajo que especifiquen la relación entre el tipo de crisis de enfermedades infecciosas y el tipo de respuesta a la crisis. Para el tipo de crisis y el tipo de mecanismos de respuesta todavía hay una falta de investigación, pero la hipótesis que combina estos dos proporciona una perspectiva para una futura investigación y una agenda de acción. Sin duda, nos impide elegir entre cisma o exageración cuando se trata de la respuesta a la crisis. Proporciona instrumentos para darse cuenta de que ningún tipo de respuesta es el más efectivo y que no todas las respuestas son igualmente efectivas en un caso concreto.

PALABRAS CLAVES: Gobernanza de redes, Responsabilidades, Gestión de Brotes, Tipología de Amenazas, Infecciosa Enfermedad

Introduction: Getting Prepared

Infectious diseases remain a threat to public health in today's interconnected world despite the decreasing burden of communicable diseases (Murray et al., 2015) and the availability of prevention and control interventions (Jones et al., 2008; Smith et al., 2014). Typical for infectious disease threats is that the timing of occurrence, duration, and path of development are not always predictable in advance. Consequently, a pressing question is how to optimally prepare for and consequently conduct an adequate response to an infectious disease threat. In the present paper we contribute to this question by arguing that it is important to distinguish different types of crisis because we can expect that different type of crisis need different types of responses. We are surprised to see how few studies in the crisis literature consider *type of crisis* an important parameter (for exceptions, see DeLeo, 2010; Nohrstedt, Bynander, Parker, & Hart, 2018). The reason might be that the literature is dominated by case studies in which the type of crisis is a given rather than a value on a variation of types of crisis (Boin, 't Hart, & McConnell, 2009). This point of view is rather peculiar from an organization science perspective where the contingency perspective plays a crucial role (Scott & Davis, 2015). A contingency perspective assumes that there is no single best response to a task (or a threat) and that not every response is equally appropriate to be effective. Whether the response is appropriate or not depends on a number of so-called contingency factors, one of which is the type of task at hand. Following this logic, preparing for a crisis or a threat would involve distinguishing different types of infectious disease threats, distinguishing different types of response to infectious disease threats and finally, which type of response is most effective for which type of response.

This paper is an attempt to demonstrate the usefulness of such an approach. A disadvantage is that, in the present crisis literature, little insights exists on types of theories, types of responses to threats and the association between both from an effectiveness perspective. As mentioned above, types of threats are only occasionally mentioned in the literature. When it comes to responses the literature is dominated by a schism (Boin, 't Hart, & Kuipers, 2018; Nohrstedt et al., 2018; Nowell, Steelman, Velez, & Yang, 2017). The literature is fueled by a continuing debate among disaster scholars and practitioners concerning the networked and hierarchical aspects of incident response (e.g., Boin & Bynander, 2015; Comfort, 2007; Jung & Song, 2015; Kapucu, Arslan, & Collins, 2010; Marcum, Bevc, & Butts, 2012; Moynihan, 2008; Moynihan & Theory, 2009; Wittmann, Jurisch, & Krcmar, 2015). Some emphasize the need for centralized control and attribute negative outcomes to a lack of centralization (often called *command and control*). Others point to the importance of emergent, transversal, and horizontal collaboration often called the *collaborative* or *network* approach) and argue that negative outcomes result from opposing centralized coordination to such settings. In order to improve our capacity to respond to potentially catastrophic events, we need to move beyond this schism and ask ourselves the question which different, potentially effective options are available as crisis response arrangements. A rather recent and important argument in the crisis-response literature is advancing the importance of "coordination." This is not surprising, given the fact that crisis response, almost by definition, requires division of labour in which an assemblage of organizations collaborate (see Christensen & Lægreid, 2016; Galaz et al., 2017; Huizer, Kraaij-Dirkzwager, Timen, Schuitmaker, & van Steenbergen, 2015; Kuipers & Welsh, 2017; Nohrstedt et al., 2018). Coordination is probably a good answer to a crisis threat but, from a contingency perspective, the question remains: what type of coordination is most appropriate for which type of threat?

In the present paper we develop the line of argument that a proper understanding of the type of threat at an early stage of the crisis can inform us about an appropriate crisis response. Thus, we present working hypotheses that link the type of infectious disease threat to an appropriate organizational response. The line of argument is constructed as follows. First, we propose a typology of infectious disease threats for human health. Second, we present different ways to respond to infectious disease threats. Finally, we propose a number of working hypotheses linking types of infectious disease threats to types of response to these threats.

Our working hypotheses are a combination of abductive reasoning combined with insights from experts of the *Centre for Infectious Disease Control* (CIDC), part of *National Institute for Public Health and the Environment* (RIVM) in the Netherlands. The CIDC is responsible for coordinating the outbreak management at national level. CIDC can call response team meetings or *Outbreak Management Teams* (OMT) meetings to which both permanent members and ad hoc experts are invited. Among the permanent members are senior staff of the CIDC (e.g., medical doctors, communication experts, epidemiologists, and policy advisors), regional public health specialists from MHS and experts representing health-care professionals (e.g., microbiologists, general practitioners, and occupational-health physicians). Experts are called upon depending on the (impending) outbreak at hand and the problems to be addressed (see RIVM's National Guidance for Infectious Disease Threats and Crises; RIVM, 2012).

Development of a Typology of Infectious Disease Threats

We adhere to Björk's statement that "Crisis management and communication require strategic thinking, and a critical important first step is the proper identification of a crisis situation … This is the area where problems usually begin" (Björck, 2016, p. 25).

We thus need to better understand the task (in our case the crisis threat) *before* starting to think about the response to the threat (Coombs, 1998). Consequently, we need to develop a typology of tasks (or crisis threats, as in our case). As mentioned before, there are scarcely any typologies available for crises, while those available have a confusing feature, in that they conceptually integrate type of threat and type of response. Although Björck (2016) has made an important contribution in pointing to the necessity of considering types of crisis and assessing the usefulness of four existing crisis typologies, he advocates a typology which combines the different aspects in one typology (e.g., including the type of crisis in terms of predictability and the implications for response). Such a typology has at least two disadvantages. First, by combining crisis and type of response it becomes difficult to explain why some crisis responses fail. A reason for failure might exactly be that there is a misfit between a type of crisis at hand and a type of response developed. Second, such a typology would exclude the possibility of equifinality as known from systems theory (Von Bertalanffy, 1968; today widely applied in configurational analysis [Rihoux & Ragin, 2008]). Equifinality is the principle that a given end state can be reached by many potential means. In our context this means that there is not necessary a one-to-one relationship between a type of crisis and a type of response, but that the same types of collaborative response can be effective for different types of crisis and vice versa. The crisis typology developed by *The International Risk Governance Council* (IRGC, 2008; an updated version published by Florin & Bürkler (2017), on the contrary, is more concerned with keeping types of risk issues presented (simple, uncertain, complex, and/or ambiguous) separate from the description of possible designs for risk management strategies ("risk-informed," "robustness-focused", "precaution-based," "resilience-focused," and "discourse-based" strategies) (Jansen, Claassen, van Poll, van Kamp, & Timmermans, 2018). This typology has, however, two other disadvantages in the light of our line of argument. First, it is not clear how the concepts presented are also applicable for the specific cases of various infectious disease threats. In the second place, there is hardly any theoretical underpinning of why certain types of risk management strategy are linked to certain risk issues.

This underdeveloped state of the literature on types of crisis has led us to develop a typology based on a large number of cases that have been dealt with during the past years in the context of the *RIVM*. It is not our intention to present this as the best or only typology, but to demonstrate the possibility and the development of such a useful typology.

To develop the typology we took the following steps: first, a list of possible attributes for infectious disease threats was developed. Second, we verified how these attributes can be retrospectively identified in a number of cases which had been on the agenda of the Dutch CIDC. Third, based on the information gained from steps one and two we composed a typology of infectious disease threats.

Development of Possible Action-Relevant Attributes for Infectious Disease Threats (Step 1)

To establish a list of possible action-relevant attributes for infectious disease threats, we collected knowledge among experts (all experienced infectious-disease control specialists who had been involved in dealing with crises arising from infectious diseases throughout the past 15 years). They were all based within CIDC and were given the task to reflect on the relevant parameters used to describe infectious-disease cases at CIDC. In a group discussion, we asked the five experts to nominate those factors which they consider to be essential to take into account when developing an effective response to an infectious-disease threat. Any disagreements within the group of experts were addressed and were extensively discussed until agreement was reached on the list of characteristics. The list was supplemented with insights from organizational studies, mainly from the literature on contingency theory (Donaldson, 2001; Mintzberg, 1989; Puranam, 2018). We then used an inductive approach to cluster the list of characteristics and combined them in a scheme of "dimensions" and "concepts." This aggregation process was repeated with the input of the experts, with logical reasoning and the above-mentioned organization-science literature. The result is presented in Table 1. Ultimately, we arrived at three concepts; knowledge, perception and scope, each with its own dimensions. *Knowledge* comprises those attributes that characterize infectious-disease threats in terms of knowledge about their causes and the approaches employed to prevent or control them. *Perception* includes those that characterize threats in terms of perceived risks to health, institutions and society. Finally, those attributes that characterize infectious-disease threats in terms of geographical location and velocity of spread, their

Table 1. Attributes of Infectious Disease Resulting From Input by Experts, Logical Reasoning and Literature

Characteristics	Dimension	Concept
(Un)expected disease	Cause	Knowledge
(Un)familiar disease		
Level of consensus on cause of threat		
(Un)known treatment options	Approach	
(Un)known preventive measures		
(Un)known control measures		
Level of consensus on threat management response		
Level of societal interest	Institutional and societal (risk) perception	Perception
Level of societal risk perception		
Level of familiarity of threat Management response among involved actors		
Level of political interest		
Level of media interest		
Level of organizational capacity of involved actors		
Level of geographical distribution	Geographical	Scope
Level of geographical boundaries		
Velocity of spread	Time	
Level of concentration on specific population groups	Groups	
(Not) life threatening	Consequences	
(No) behavioral change necessary		
(Not) threatening to organizational structures and –processes		
Level of political consequences		
Level of political downside		

concentration among specific population groups, and the consequences for (political) daily life are classed under *Scope*. We are fully aware of the fact that this Table does not constitute a definitive scheme for the classification of infectious-disease threats. Our principal intention here is to illustrate that these threats can arise in very different forms.

Retrospective Application of Characteristics to Selection of Cases (Step 2)

In the following step, we studied whether dimensions and concepts can effectively and usefully be applied retrospectively to a number of cases which were on the agenda of CIDC (see Mollers, Isken, & Swaan, 2015; Schreuder, Urbanus, & Swaan, 2014). We focused on the cases of infectious-disease threats dealt with by the CIDC in the years 2013 and 2014. Cases were selected that required coordinated outbreak management at the national level. In total nine incidents met these criteria: a measles epidemic, an outbreak of Salmonella Thompson, a threat of polio virus importation by Syrian refugees, an outbreak of Klebsiella Pneumoniae in a nursing home, the discovery of an invasive mosquito type, an outbreak of MERS-CoV in the Middle East, MERS-CoV patients in the Netherlands, an outbreak of influenza AH7N9 in China, and an Ebola outbreak in Africa.

The experts proved able rather straightforwardly to assess the characteristics for each of the nine cases as “low,” “medium,” or “high.” By aggregation, and in consultation with the experts, we arrived at a score (“low (0)” and “high (1)”) at the level of the concept.

Proposed Typology of Infectious-Disease Threats (Step 3)

Each (potential) crisis is scored on three dimensions using two possible scores.[1] The thus resulting eight possible situations can be positioned along a spectrum of degree of complexity. This is related to the fact that “complexity” is considered an important concept in discussions in the theory and practice of crises. It is, for example, prominent in Sandman’s well-known formula, in which the sum of the degrees of vulnerability and hazard, divided by a measure of the capacity to withstand them, forms a measure of the likelihood of a calamitous outcome’ (Sandman, 1993) or other concepts which figure prominently in the literature (e.g., “high problem severity,” Cook, 2010; Nohrstedt et al., 2018). However, rather than considering complexity as a constant (“crisis = complexity”), as is often the case, our classification considers it as a “variable” distinguishing crises by degree of complexity. Given the fact that the degree of complexity is a well-known concept in the field of organizations studies (see Campbell, 1988; Perrow, 1986), it seems worthwhile to consider it as a useful link between the world of crisis and the world of organization, since it can help to formulate propositions about the fit between type of crisis and type of coordination. In a *simple* problem the necessary components and the order in which to combine them are known in advance. A protocol can be followed and repeated with little expertise and can be expected to produce roughly reproducible results (see Westley, Zimmerman, & Patton, 2006). A *complicated* problem requires expertise and knowledge, or a multiplicity of inputs to produce an algorithm.

Complex problems (often nowadays called "wicked") , on the other hand, lack protocols or "correct" answers, while previous successes do not necessarily guarantee success in the future. In short: there is uncertainty about the results, especially given the unpredictable interactions between the component parts.

By combining the scores for the three identified concepts (see Table 1) with our understanding of the degrees of complexity (simple, complicated, or complex) we derive the following categorization of infectious disease threats (see Table 2):

1. An infectious disease threat is *simple* if the level of knowledge is high, and the level of perception and scope are low; protocols are available and can be repeated as effective crisis response.
2. An infectious disease threat is *complicated* if the level of perception is low and the level of knowledge and scope are high; there is sufficient knowledge available about cause of disease and response approach and the scope of threat is low; however, the threat is subject to uncertainties with regard to institutional and societal perceptions and additional expertise is therefore required in order to optimally respond to the threat.
3. An infectious disease threat is *complex* if the level of perception is high or there is a lack of knowledge; the combination of a lack of knowledge and a high level of perceived institutional or societal risk translates into multiple uncertainties. Protocols are limited or unavailable. A more tailored approach is necessary.

Distinguishing Different Types of Response for Multi-Actor Systems

In recent studies of disaster management, network governance of crisis response has gained considerable attention (Christensen & Lægreid, 2016; Comfort,

Table 2. Overview of the Typologies of Infectious Diseases, Their Underlying Situations and the Incidences in 2013/2014

Situations	Incidences 2013/2014	Typology of infectious disease threat
K↑, P↓, S↓	Threat of poliovirus importation through Syrian refugees, outbreak of Klebsiella Pneumoniae in nursing home, discovery of invasive mosquito type, Influenza AH7N9 outbreak in China	Simple
K↑, P↓, S↑	Salmonella Thompson outbreak	Complicated
K↓, P↑, S↑		Complex
K↓, P↑, S↓	MERS-CoV patients in the Netherlands	
K↑, P↑, S↑	Measles epidemic, Ebola outbreak in Africa	
K↑, P↑, S↓		
K↓, P↓, S↑		
K↓, P↓, S↓	MERS-CoV outbreak in Middle East	

K = Knowledge, P = Perception, S = Scope

2007; Comfort & Kapucu, 2006; Galaz et al., 2017; Huizer et al., 2015; Kapucu et al., 2010; Kapucu, Augustin, & Garayev, 2009; Magsino, 2009; Moynihan & Theory, 2009; Nowell & Steelman, 2013; Nowell et al., 2017). As noted previously, Nohrstedt et al. (2018) produced a systematic literature review on *Managing Crisis Collaboratively*, Kuipers and Welsh appealed, in their *Taxonomy of Crisis and Disaster literature*, for more attention to be paid to *inter alia* "Networked Crisis Management" (Kuipers & Welsh, 2017, p. 280), while Boin et al. (2018, p. 32) claim in *The Crisis Approach* that "In fact, the crisis response in modern society is best characterized in terms of a network." The current consensus thus appears to favour network governance, which in turn leads to the question: what type of network governance? According to the contingent perspective we follow here, the question becomes which type of network governance (or "networked enterprise" as (Nowell et al., 2017, p. 1) call it is appropriate for which type of crisis threat?

In order to distinguish between types of network governance we build on insights from the more general literature on the collaborative governance response perspective. This has undergone significant development in recent years (see e.g., Amsler & O'Leary, 2017; Bryson, Crosby, & Stone, 2015) and has proved helpful in building our working hypothesis. It recognizes a multi-actor system as the unit of analysis. Moreover, it recognizes that the governance of multi-actor systems can take different forms (Boin & Bynander, 2015; Nowell et al., 2017; Provan & Kenis, 2008).

One of the most often used classifications of collaborative governance is that published by Provan and Kenis (2008) and St. Clair, Hicks, and Isett (2017). Provan and Kenis (2008) distinguished three forms of governance: shared governance, lead-organization governance, and network administrative organization (NAO) governance. Since the publication of their article, additional forms have been introduced and discussed: combined lead/NAO governance and core-periphery governance. Before formulating our preliminary theory, which is composed of several contingency propositions (i.e., spelling-out the relationship between type of threats and types of governance response) we will briefly describe the logic of these different governance forms (see Figure 1).

In the *shared* or *member-led governance* form, networks govern themselves without members delegating authority to a third party. The *lead organization governance* form, on the contrary, is characterized by a situation in which one of the actors in the network has the responsibility of guiding the network towards its goals. In addition, a lead organization simultaneously maintains responsibility for its domain of operation. In the *NAO governance* arrangement, the network members delegate authority to a third entity, the entire role of which is to coordinate the activities of the network members, make decisions, and take certain actions on their behalf. An important distinction between shared governance on the one hand, and the lead and NAO governance forms on the other, is that the latter are "brokered," which means that the network governance is administered by and through a single organization and thus clearly entails some division of labor regarding the governance at the network level. The key distinction between the two brokered forms, the NAO and the lead organization, consists in whether the governing entity

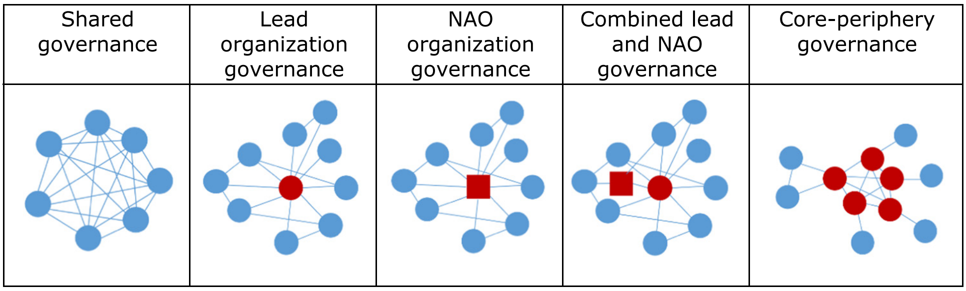

Figure 1. Types of Network Types of Response for Multi-Actor Systems or Network Governance

has operational responsibilities within the network, beyond the responsibility for its governance. A fourth form, which was not described in the original publication of Provan and Kenis (2008) but which has been observed in a number of cases, is a hybrid of the *combined lead organization and NAO governance*. In this situation a network with an organization having operational responsibilities is supported by a NAO. Lead network organizations might become overburdened, for example, because of the number of network members or because of necessary reporting. Certain tasks are therefore delegated to a third organization, while at the same time it is essential that a single operational organization should exercise the overriding leadership. A fifth form, which has been introduced in a recent publication by Nowell et al. (2017), in the field of crisis response is *the core-periphery governance* form. It is similar to the lead-organization form but, in this case, the lead is taken, not by one but simultaneously by a number of organizations having operational responsibility. The rationale for this form might be the fact that the network is differentiated among subgroups (for health, safety, education, policy, etc.) comprising organizations which have a role to play, though they may not necessarily be considered part of the core network. Of these it is unlikely that all will share the trust in the capacity of a single NAO to govern the network effectively. In this case it may be governed by a core composed of one of the organizations from each of the different subgroups; it will then function as a shared network- governance form.

In what follows we will introduce the third part of our argument, formulating propositions on the appropriate response to specific types of infectious-disease threats.

Towards a Working Hypothesis of Network Governance Responses to Infectious Disease Threats

In this final section, we present a number of testable propositions that we have developed. Taken together, they form the basis for an approach linking types of governance responses to types of infectious-disease threats. We propose that a response to the threat of an infectious disease threat may be judged effective when a fit exists between the type of threat and the type of network governance response deployed (Figure 2).

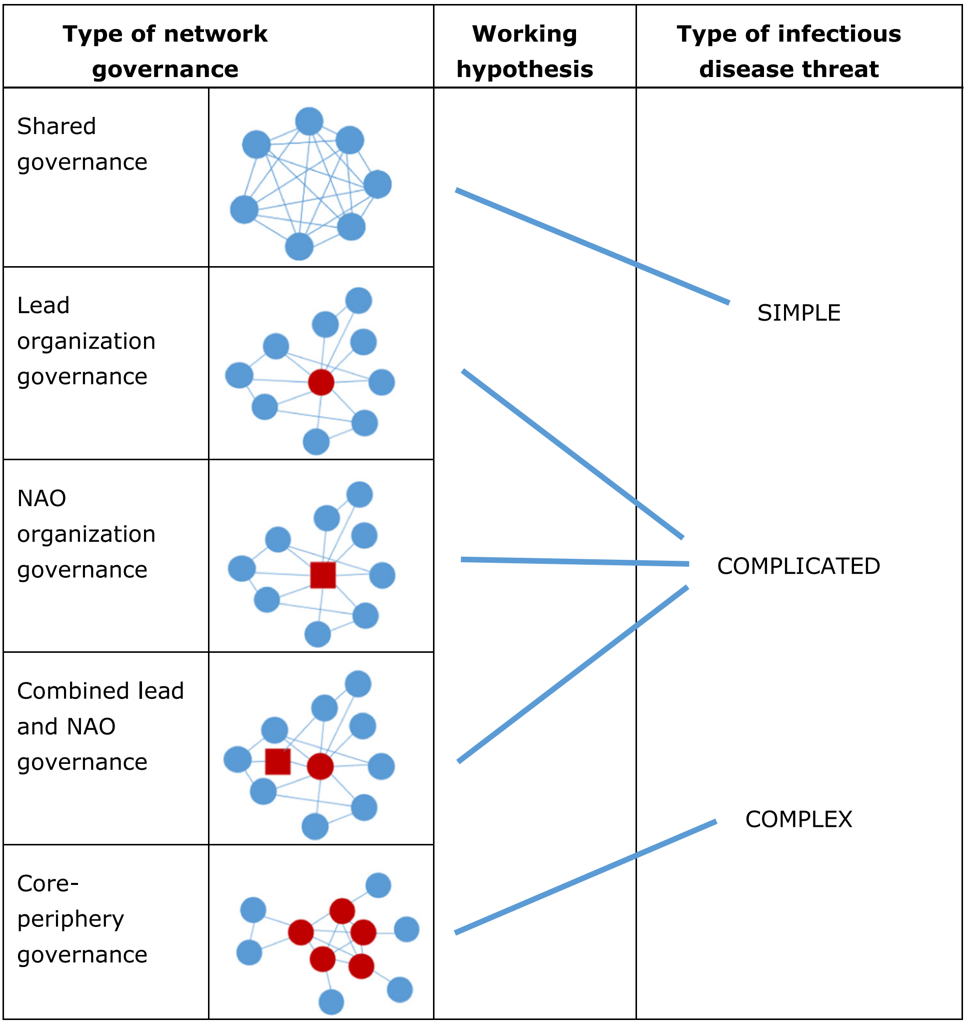

Figure 2. Visual Presentation of the Working Hypothesis

We propose the following propositions, to be tested in future situations:

P1: *If an infectious-disease threat has been indicated as simple, then a shared governance approach involving partners who routinely work together and share all required knowledge will be the most effective and timely response to deal with the threat, with the understanding that all other parameters are held constant.*

P2: *If the threat has been indicated as complicated, then a network administrative organization (NAO) governance approach will be the most effective and timely response to deal with the threat, with the proviso that a functioning NAO is* *already in place and with the understanding that all other parameters are held constant.*

P3: *If the threat has been indicated as complicated, then a lead-organization governance or combined lead/NAO governance will be the most effective and timely response to deal with the threat, under the condition that a NAO organization is not already in place and with the understanding that all other parameters are held constant.*

P4: *If the threat has been indicated as complex, then a core-periphery governance form will be the most effective and timely response to deal with it, with the understanding that all other parameters are held constant.*

We will elaborate on each proposition in relation to the type of risk: simple (P1), complicated (P2 and P3) or complex (P4).

Fit Between Simple Risk and Network Governance Response

Simple infectious disease threats are defined as those where substantial knowledge about the threat and interventions is available, generally not perceived as a large institutional or societal risk, and with a limited scope (see Table 1). An example of such a case would be an outbreak of gastroenteritis or respiratory infection in a school.

In these cases, the most effective network governance response will be a joint discussion by a group of relevant actors about the most appropriate crisis response, often in line with previously developed guidelines. Guidelines for response to outbreaks of infectious diseases are often developed among stakeholders based on grey and published literature and expert consensus. Guidelines can thus be seen as established shared knowledge. Proposition P1 is in line with the approach to simple risks, as defined by IRGC, suggesting risk governance "using existing routines to assess risks and possible reduction measures" (IRGC, 2008).

The number of stakeholders involved in the response to simple risks will most likely be limited; they may well be familiar with one other, based on shared experiences in previous cases and/or guideline development. Since it is unlikely that other actors will become active, or that new insights will evolve during the threat, it can be optimally governed by a group of actors and institutions who are used to collaborating and can communicate quickly and consistently. Stakeholders know their role to play in the network and will naturally deploy themselves in the most appropriate way.

We therefore advance the following proposition (P_1):

P1: *If an infectious-disease threat has been indicated as simple, then a shared governance approach involving partners who routinely work together and share all required knowledge will be the most effective and timely response to deal with the threat, with the understanding that all other parameters are held constant.*

Fit Between Complicated Risk and Network Governance Response

A *complicated* infectious-disease threat can be defined as one for which substantial knowledge about both threat and interventions is available; the scope of the threat is limited, but it is perceived as a large institutional or societal risk (see Table 1). An example of such a case could be a regional or national outbreak of severe gastroenteritis caused by a food pathogen, where the likely source is a food product sold through different supermarket chains. The fact that the threat is expected to attract substantial attention by specific groups, and/or the media and/or politicians, implies that it cannot be dealt with exclusively by an inner circle of experts. Such a threat should, from the beginning, be considered as one which will attract wide attention and needs to be appropriately managed to be effective. The fact, however, that there is sufficient knowledge about the threat implies that more knowledge is not expected to change the response during the evolution of the crisis. In such a case a NAO would be most suitable to govern the network, paying sufficient attention to the different information needs of the varied group of stakeholders to achieve the desired network response (e.g., supermarkets will be informed which products to take out of stock, consumers are strongly advised to throw away contaminated products and medical professionals will be alert to recognize symptoms in time to treat patients). A NAO has the advantage that it can obtain the necessary information from the different partners in the network and can process it in a target group-specific way and at the same time can assure the consistency in the type of information provided. The NAO can also easily get back to the different partners in the network in order to collect additional information based on feedback it receives. A NAO is in the position to make decisions on whether to involve newly emerging societal, political or media actors. A well-functioning NAO has the advantage that it is not associated with specific interests but is principally concerned with containing the risks of the threat. The disadvantage of a NAO is that it takes time to install or maintain. A NAO does not need, however, to be installed for each new threat; one can already in place to deal with consecutive threats (a function which could be part of CIDC).

If this cannot be realised, then the NAO might be found too sluggish as a governance form. In such a case it may be preferable for a lead organization to take an explicit network governance role. The advantage of this would be that it is already active in combatting the threat and needs only to assume the additional responsibility of facilitating the progress of the overall network toward its results. A lead organization assuming such a role would, however, need to be cautious with respect to concerns regarding potential problems of potential internal and external legitimacy (Human & Provan, 2000). On the one hand, the lead organization needs to be accepted as a "trusted partner" among the other network members (internal legitimacy), but must be also perceived as a "trusted advisor" on the different perceived issues regarding the infectious-disease threat among the other actors. These could be involved groups, the media or the politicians. These issues might be dealt with by putting in place a second NAO in parallel.

The above leads to the following two propositions (P2 and P3):

P2: *If the threat has been indicated as complicated, then a network administrative organization (NAO) governance approach will be the most effective and timely response to deal with the threat, with the proviso that a functioning NAO is already in place and with the understanding that all other parameters are held constant.*

P3: *If the threat has been indicated as complicated, then a lead-organization governance or combined lead/NAO governance will be the most effective and timely response to deal with the threat, under the condition that a NAO organization is not already in place and with the understanding that all other parameters are held constant.*

Fit Between Complex Risk and Network Governance Response

A *complex* infectious-disease threat is characterized primarily by absence of knowledge about it (in terms of the cause and/or the measure to be taken). Furthermore, the available knowledge may be contested (e.g., with regard to the effectiveness of particular control measures such as vaccination), see Table 1. It is important to realize that an infectious disease threat can also be complex when it is perceived as a high institutional or societal risk. Outbreaks of infectious diseases are often complex, in the sense that they are characterized by incomplete and/or contradictory information, and also varying needs of stakeholders that can be difficult to recognize and change while the outbreak is developing. A further source of complexity is that, during this process, many more actors may become active, believing themselves to have a stake in the outbreak, while others with a clear stake might not become active (even in the presence of well-established knowledge about the infectious disease threat). This makes it unlikely that an orderly response will naturally develop. In such a case, it can be expected that the evolvement of an actor set may be unclear or even confusing. Despite the fact that the first actors to be dealing with an infectious-disease threat (such as CDCs) have a professional/technical background, it is important to notice that even in a situation of availability of knowledge (which is generally the main concern of the technical professionals) an infectious disease threat can develop as complex. Such a case could be an outbreak of a well-known pathogen, causing severe diseases and having a disruptive impact on the society; Ebola and measles have provided recent examples. The disruptive impact may take the form of a high rate of depletion of resources and the emergence of new ethical discourses. These may give rise to groups opposed to one other in the societal debate about the magnitude and appropriateness of measures the authorities need to take and the society is capable of absorbing.

For dealing with a complex infectious-disease threat, a *simple* or *complicated* governance form is unlikely to prove adequate. These simplify the issue at hand and may fall back on protocols and formulas which, though they might work for problems designated "complicated," are likely to produce unintended or perverse consequences for complex problems. A shared governance approach, lead organization or NAO is also not appropriate because, with their narrow (but specialized) lens, information or insights produced by others may be missed. Weick's study on the West-Nile Virus (WNV) incidence in New York City in 1999 (Weick, 2005) is a good example in this respect. CDC was not taking notice of information provided by a veterinarian about unusual issues with animals during the time of the infectious-disease outbreak. If the CDC had been able to make the connection between the various pieces of information available among actors during that time, the development of a response could have been more timely and effective (Keller et al., 2012). We therefore propose a core-periphery network to be the most appropriate in the case of complex problems. A core-periphery structure is theorized by scholars as having the potential benefits of both the cohesion and stability of a closed network, while also having the flexibility for the network to grow and recognize the importance of new actors that become involved because of the disease outbreak. Such a structure could prove especially relevant, given the fact that a complex problem can be expected to consist of many different sub-processes. For example, the integration of scientific knowledge about the pathogen and risk groups with laboratory and epidemiological processes, could lead to better understanding of the actual outbreak. This in turn could facilitate the development and support of the implementation of context-specific control measures, and the communication of (targeted) risk to health care professionals and the public. The actors involved may each have their own individual and network goals: for example, patient care or water management in the case of the WNV. At the same time the core of the network can develop governance responsibilities in the same way as the lead organization can. We therefore advance our last proposition (P_4):

> P4: *If the threat has been indicated as complex, then a core-periphery governance form will be the most effective and timely response to deal with it, with the understanding that all other parameters are held constant.*

Discussion and Conclusions

The crisis-response field, in general, and the infectious disease response literature in particular, has recently embraced the fact that "… crisis response in modern society is best characterized in terms of a network." (Boin et al., 2018, p. 32).

This is an important statement, but the field remains nascent with regard to understanding which specific structural governance arrangement will perform best under which conditions (the condition focused on in this paper being the type of crisis). The present paper is intended as a contribution to this question through the development of a number of working hypotheses.

The hypotheses are based on a number of elements. We have demonstrated that infectious-disease threats may arise in various forms and that the same holds for the responses to the threats. We argue that there is no automatic relationship between the shape of the threat and its response. Empirically speaking, it is very likely that a particular threat will be addressed by an inappropriate shape of response. In response to this possibility, we have demonstrated that working hypotheses can be formulated about which shape of organizational response is most appropriate for which type of threat.

In the process of subjecting the working hypothesis to empirical research we are convinced that the typology in Table 1 will be strengthened. We especially recognize the need to make further differentiation among the aspects related to "perception." Recognizing the international variation in responses to (perceived) environmental health risks, Clahsen et al. (2018) recently explored the variety of theories and frameworks related to better understanding of the perception of risks. It will be interesting to continue this exploration to understand how the variation of (risk) perceptions among stakeholders influences the type of threat and the best fit with the response to the threat.

Moreover, the development of the typology of infectious-disease threats has been based on input from experts in a single organization (CIDC) and in one country (the Netherlands). It is important to further analyze whether this typology also holds with other groups of experts in other institutional settings and in other countries. What we have demonstrated, however, is that our assumption of the different forms that crises may take is confirmed by experts in the field. Empirical testing of the working hypotheses may, it is hoped, help to prevent the deployment of inappropriate instruments, when dealing with infectious-disease threats, and discourage the tendency to set up new organizations or structures, rather than strengthening existing bodies, as proposed by Kickbusch, Cassels, and Liu (2016). Appreciation of the circumstances of a particular case may help our awareness of the different governance mechanisms available. Several questions remain on how to specify the type of crisis in a concrete practical setting. A possibility might be to submit the question to a panel such as, in the Netherlands, the Outbreak Management Team at CIDC, immediately after a threat has been reported. Analysis of the characteristics of a crisis will help to avoid too hasty conclusions on the required response. We believe that real-time scoring of the characteristics can facilitate discussion among experts. This will increase the likelihood of a correct assessment of the type of crisis and facilitate recommendation of the type of response required. For a crisis labeled *complex*, the first reaction of this panel should be acknowledgement that they do not know the responses by definition and that they mainly concentrate on what might be missing (widening the lens; Adner, 2013) and not automatically deploy what is there. Also retrospectively, cases can be analyzed using this typology, in order to support evaluation and the learning process of not only individual professionals, but especially organizations and networks. The methodology to score the aspects in this typology can be improved at least in two different ways: (i) through exploring the applicability of statistical modelling techniques and (ii) enriching the scoring process with dynamics created in group discussions to in depth understand the threat and circumstances "at hand."

For the presentation of the types of governance forms in this paper, we found it necessary to borrow insights from the more general field of the "governance of networks." These have enabled us to move beyond the old schism of "control and command" versus "networked" approaches, although further work may suggest the consideration of still other possible effective governance mechanisms and throw more light on other functioning mechanisms that may already be in place. Such research would be a worthwhile endeavor. The propositions formulated will need to be empirically validated (or possibly invalidated) in a prospective series of real crises and outbreaks. Only in this way can progress be achieved in a field, the main concerns of which are the improvement of its theoretical basis and the realisation of practical solutions within it. Finally, all our propositions end with the sub-clause "other parameters being held constant." We know that this ideal cannot in practice be realised; we therefore need to study, in future research, the effect of other contingency factors (e.g., size of network, its (perceived) legitimacy, maturity, and stage of development) apart from the type of infectious-disease threat (or "task specificity").

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Note

1. Three concepts with two possible values leads to eight different unique situations (2^3)

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