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Adaptive organizational network response in a crisis: The case of five European airports during the COVID-19 pandemic

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Abstract

The COVID-19 pandemic posed unprecedented challenges to the joint organizational response of private and public and here especially public health organizations. This is particularly true for airports as central connectors of global travel and trade. For five European airports, we analyzed the interorganizational response based on input from 66 of the 87 different airport partners, using two fictitious scenarios derived from public health practice. We applied organizational design theory and quantitative (network) analysis to show how the four fundamental problems of organizing have been tackled at airports, i.e., task distribution, task allocation, rewards, and information provision. This article shows how the response to COVID-19 in the airport setting needs to be solved within broad and flexible public administrative networks. The thorough understanding of organizational network responses in emergency management following from this article supports future preparedness efforts to deal with complex known and unknown public health threats.

Evidence for practice

- The COVID-19 response at airports is a truly intersectoral activity which is highly complex to organize due to the involvement of many partners.
- There has been a broadly shared common motivation among health, public health, air transport, Crisis and security sector organizations to contribute to the COVID-19 response.
- Despite the *Ex ante* COVID-19 task division and allocation in plans and guidelines, situational information exchange and, as a result, ad hoc coordinating roles during the actual disease response activities were required.
- The prescription of public health tasks and their implementation in the literature and guidelines corresponds suboptimally with the actual whole-of-airport operationalization of tasks.
- We suggest the use of a parsimonious framework, based on the four fundamental problems of organizing, to guide planning and response during complex crises.
- Emergency management situations at airports, such as in the case of the COVID-19 response, need to be tackled within broad and flexible public administrative networks.

Any appendices in the supporting information referenced may be accessed from the Wiley PAR Website (https://onlinelibrary.wiley.com/journal/15406210).

INTRODUCTION

International travel and transport have been an indispensable condition for the globalization of societies and economic growth. At the same time, travelers and transported goods can also facilitate the international spread of disease that can threaten economic and societal activities. Airports are premier examples of settings where both international traffic and prevention and response to internationally spreading disease take place. As such, airports are settings in which the transport and public (health) sectors need to collaborate to provide important and sometimes conflicting services to modern society. Both sectors are supported by the global juridical backbone, the International Health Regulations (IHR). These regulations bind state parties to, on the one hand, implement minimum requirements for airports and other so-called 'designated'[1] points of entry to contribute to public health emergency response. On the other hand, states are bound to formally position this response against a minimum of interference with international traffic and trade (World Health Organization, 2016, p. 41–42).

The COVID-19 pandemic posed an unprecedented challenge to the provision of public services at airports. In 2020 and 2021, a high level of flexibility and creativity was needed from emergency mangement and governance structures in place. Many countries implemented public health measures such as flight bans and entry screenings to mitigate the COVID-19 impact, thereby interfering with international travel and trade. In these—often—new crisis situations, previous studies have shown several practical challenges. The communication to airport partners and the public amidst many uncertainties on this crisis' essence, the cooperation among new partners across sectors and working levels, and the volatile demands in trained public health staff and staff in the air travel sector are just a few of many examples of these practical challenges (De Rooij et al., 2022; Kleine-Kampmann et al., 2021). A particularly illustrative case of how challenging COVID-19 response at airports remained, was experienced at Schiphol Airport in the Netherlands in November 2021. Despite experience gathered during the pandemic with the implementation of screenings, testing streets and measures at the airport, it proved extremely difficult to suddenly accommodate and test over 600 passengers from two planes. This unprecedented situation resulted in great difficulties to cooperate and coordinate across sectors (Berenschot, 2022; Moses, 2021).

The COVID-19 pandemic clearly showed that despite the fact that airport preparedness has been high on the international public health agenda, new response situations can occur that do not fit the experience of the past, which requires a unique approach by the airport partners of all sectors (De Rooij et al., 2022). Ansell et al. (2021) recently drew a likewise conclusion regarding the COVID-19 response in general. They describe the COVID-19 pandemic as one out of many looming problems of "surprising, inconsistent, unpredictable and uncertain" essence which require new forms of public administration and leadership (Ansell et al., 2021, p.949). The aspect of crisis in the airport setting, therefore, probably requires a unique approach but has been hardly studied.

We use the COVID-19 response in the airport setting to show what dealing with complex crises in public administration practice means in a similar way asvan den Oord et al. (2020) did in a port setting. In this study, we conceptualized the airport as an organizational network (ON) consisting of many different public and private organizations, as the provision of the different public services clearly requires (Kenis & Raab, 2020; Raab & Kenis, 2009). Learning about the functioning of ONs during the complex and even turbulent COVID-19 crisis is difficult. We chose the holistic framework to assess ONs providing public services that has recently been proposed by Kenis and Raab (2020) who apply the so-called organization design theory in this regard. This basic organization theory states that every organizational form needs to solve the same four fundamental problems in order to reach the organizational goal, being task division, task allocation, reward provision, and information provision (Kenis & Raab, 2020; Puranam et al., 2014). In this study, we apply the organizational design theory to a cross-case analysis of the COVID-19 response at five European airports, with the aim to answer the research question: *How have the four universal problems of organizing been solved by the multi-sectoral ONs involved in the COVID-19 response at European airports?* By answering this question, we aim to extend the scientific knowledge on governance of ONs during public crises at airports.

THEORY—THE AIRPORT AS A GOAL-DIRECTED ORGANIZATIONAL NETWORK

Puranam et al. (2014) argue that any organization needs to successfully divide the labor for their activities and integrate subsequent efforts again to reach the organizing goal(s). They further divide these processes into four universal problems for organizations. Kenis and Raab argue subsequently that this theory can also be applied to ONs with clear boundaries, a common goal, and multiple agents which all contribute to these goals (Kenis & Raab, 2020).

The airport has geographical boundaries as it has a physical location at which multiple agents from different sectors and working levels are acting toward a common goal. These sectors can be divided in several ways, but in relation to their field of functioning, we distinguish three main sectors: the air transport sector (consisting of partners such as the airport operator and administration, airlines, handlers, conveyance operators, etc.) public health and health sector (airport medical services, ambulances, public health authorities, cleaning company, etc.), and a

Division of labor	Integration of efforts
Task division Specific tasks needed to be carried out in order to perform COVID-19 response in the airport setting.	*Reward provision* The motivations that partner organizations have to contribute to the COVID-19 response in the airport setting.
Task allocation Connecting the divided tasks to the different partner organizations that are active in the airport setting.	*Information provision* The flow of information among partner organizations that is needed to execute and/or coordinate the different tasks.

FIGURE 1 Overview of the universal problems to be solved according to the organization design theory applied to the airport setting. *Source*: Based on Puranam, 2018 in: Kenis & Raab, 2020.

crisis and security sector (airport security, crisis/emergency center, fire fighters, customs, police, the military, etc.). Each sector has partner organizations on local, regional, national, and international working levels. The involvement level with the local airport level depends upon the governance system of the sectors in the particular country. Generally, we distinguish between more centrally or federal ways of governance.

The common goal for which these sectors cooperate, as is set out in the introduction, is at least bidimensional: international traffic and trade is facilitated under the condition that the consequences are manageable from a public health perspective. Although we have no evidence that in practice this is the goal that forms the basis for organizing at the airport, we nonetheless can assume that with the basis in the IHR, this is the ultimate goal to which a way of organizing should be set up. We therefore consider the outbreak response system at an airport as an intersectoral, interorganizational and goal-directed network for which the organization design theory is applicable (Figure 1).

Division of labor

Goals of an organization or other forms of organizing need to be divided into different tasks done by parts of the organization. Division of labor within an ON can either happen ex ante by a predefined architecture of tasks, roles and plans, or ad hoc in response to a specific situation. Ad hoc differentiation is dependent on the flexibility of cooperating and coordinating mechanisms, such as hierarchical relations within a sector, self-organization by sub-entities of the ION, and joint decision-making in the ON. Factors steering the division of labor are among others particular skills, preferences, costs, and accountability (Puranam et al., 2014). Based on Puranam et al. (2014), the division of labor is subdivided in the problem of task division and task allocation.

Task division is the categorization of the overall goal into specific tasks to be carried out (Kenis & Raab, 2020; Puranam et al., 2014). Based on an explorative review in scientific literature and guidelines provided by public health and air transport international advisory organizations (Appendix A in the supporting information), we distinguished 19 core tasks at airports for emergency manegment. These tasks are used as outline for dividing tasks in the airport setting. It should be noted that all of the identified tasks directly point to only one of the two public services at stake, being response to infectious disease threats. The other one, preventing interference with international traffic and trade, is done implicitly. Also, the operationalization of public health tasks in the airport setting has not been described in the literature.

Task allocation involves the process of connecting identified tasks to agents in the network (Kenis & Raab, 2020; Puranam et al., 2014). Tasks could be allocated on several levels: to individuals, teams, departments, organizations or sets of organizations in the ON. Task allocation in the public health response at airports is well prescribed for formalized tasks, involving only a limited number of airport partners (ECDC, 2014; Martin & Boland, 2018; WHO, 2009, 2012). Also, the WHO guidance for points of entry prescribes airport governance structures to be involved in the handling of a PHEIC (World Health Organization, 2012). In practice, however, ex ante task allocation at airports is described as challenging by the few scientific studies touching upon it (Bakari & Frumence, 2013; Gosadi et al., 2015; Warren et al., 2012). In particular, these studies show how prepared response plans describing ex ante task allocation were either nonexisting or put aside during response situations.

Integration of efforts

Integration of efforts is done through cooperation and coordination mechanisms. Cooperation requires motivation or rewards, while coordination is done through information flow (Puranam et al., 2014).

Reward provision entails any form of motivation for organizations and individuals in these organizations to actually perform their tasks (Kenis & Raab, 2020; Puranam et al., 2014). Motivations can be intrinsic or extrinsic, monetary or nonmonetary, explicit or implicit (Puranam et al., 2014). Furthermore, they can be derived from the personal, personal-organizational or societal level (Kenis & Raab, 2020). In international guidelines, the motivation to handle originates often from the legal obligation to act in the IHR, the Decision 1082, or ICAO guidelines. In other words, it is a top-down and extrinsic motivation of 'ought' to perform. In the literature, identified factors that negatively influence motivations are a lack of 'professional development training', and a lack of 'understanding of the IHR' (Bakari & Frumence, 2013; Gosadi et al., 2015). In a study by Bongiovanni and Newton (2019) furthermore complacency, stress, skills, experiences, repetitiveness of tasks, naturality of the process, reality of costs, economic goals and competition, the perceived risk (likeliness and impact), and cultural aspects are named as reasons for performing tasks within the organization. They also state that improper information sharing between different sites—not knowing each other's interests—can impair motivation to act (Bongiovanni & Newton, 2019).

Information provision entails the flow of information among individuals and organizations to execute a task and coordinate actions (Puranam et al., 2014). Information can flow between partners via face-to-face interactions or technological mediums. Or information flow can be prevented through ex ante coordination via clear allocation and standardization of tasks (Kenis & Raab, 2020).

International guidelines hardly prescribe communication lines (WHO, 2009; IATA [unknown]) demanding local designation of roles represented in the plans. In practice, it is shown that the pure existence of a plan is not necessarily enough to decrease the need of information. A study by Bakari and Frumence (2013) assessing IHR implementation in Tanzania describes how guidelines were not reached by airport health workers due to a lack of dissemination funds. Also, a study by Martin and Boland (2018) described a lack of adherence to communication protocols during a full scale exercise at an Irish airport.

Little information is available on 'how' information is shared during public health events at airports. Studies refer to 'calling' or to 'contact information' among authorities, but any reference to required communication structures such as meetings or specific communication technology is lacking—while it does matter. Bakari and Frumence (2013) state how a lack of hardware capacity is negatively impacting communication. In an evaluation of a full scale simulation exercise, factors such as restricted physical access to a fax machine, the telephone signal and catching background noise during telephone conversations were mentioned (Martin & Boland, 2018).

METHODOLOGY

By means of a survey study among all partner organizations involved in the COVID-19 response at five European airports that have been designated in accordance with the IHR, the division of labor and integration of efforts are analyzed descriptively and in a quantitative network analysis. We use the COVID-19 response in the airport setting in general and in two hypothetical response scenarios derived from public health practice, and will report here the cross-case analysis.

Population and case selection

We asked the EU Healthy Gateways joint action network to connect us to airport contact representatives. Selection criteria for airports were formal designation in accordance with the requirements for points of entry as stated in the IHRand the availability and willingness of a key contact person to contribute to partner mapping and invitation. Furthermore, during the sampling of the airports, we aimed for different sizes of airports, and an geographically equal spread over Europe.

Participant sampling

Subsequently, one or two key contact persons at each included airport selected three different partner groups which together made up the entire network that was subject of analyses.

- *Group 1*: Locally involved partners in the COVID-19 response at the airport, based on 19 core response tasks identified via a literature review. Although we focused as much as possible on local partners, during participant sampling many regional partners were brought up. For all regional or nongovernmental national parties, the involvement was discussed with the key contact person and if needed these were also included.
- *Group 2*: Bodies or meeting structures involved at the airport uniting several partners,
- *Group 3*: National, governmental partners in the response.

Members of group (1) were invited per e-mail to join the study by completing a questionnaire representing the organization they were affiliated at. Members of group 2 were only invited if a clear representative could be identified. Other meeting bodies (2) and all national, governmental partners (3) fell outside the scope of data collection but were included as partners in the questionnaire for other participants to refer to. In addition, the local partners could suggest any missing partners to further complete the involved network.

Data collection

Local partners were invited to participate either directly, explicitly naming the key contact person as broker for their contact information, or by the key contact person. The questionnaire and several reminders were sent per e-mail and/or via different mediums by the key contact person. Data collection started in the first week of September 2021 and ended by sufficient response (80 percent of local partners) or inabilities to further extend the response rate. Data collection ended at the end of November 2021 for the last airport. Data were stored and handled in accordance with Europe's General Data Protection Regulation.

Questionnaire

The questionnaire consisted of three parts and an informed consent page and can be found in Appendix B in the supporting information. In part one of the questionnaire, baseline information was collected about the individual representing an organization based on job title and function, and about the organization represented

from a prior set-up list to which participations could make additions. This prior set-up list was derived from the partner selection with the key contact and was important to place the input of the participant in the network analyses. Lastly, we asked participants to select their contact network that had existed prior to the COVID-19 response situation based on at least monthly contact. This information was used as a comparison to the contact network that was used in response situations.

The second part focused on the tasks and roles of an organization in the COVID-19 response and coordinating mechanisms. Participants scored either direct involvement through executing parts of a task, indirect involvement to facilitate others that were executing a task, or no involvement. The response tasks had prior been selected from literature, any additional response tasks could be added by participants. Furthermore, several questions focused on the extent of ex ante coordination of response tasks and the used mechanisms and involved partners in ad hoc coordination of response tasks at the airport. Lastly, we asked participants to score several motivations to be allocated with a task by the network, and their own motivations as an organization to contribute to the response. Each time, also additional motivations could be named by participants.

The third part consisted of the presentation and reaction to two different hypothetical response scenarios. The first scenario involved a notification of several ill passengers suspected for COVID-19 on board of an aircraft approaching the airport. The second scenario involved the request to implement a new entry-screening obligation within 24 h. For each scenario, we asked the respondents whether they would be involved, the timing of involvement, the timeliness of involvement, any ex ante coordinating plans for the case, what were contacts to whom or from whom information would be sent, the reasons for sending and receiving information, and the use of different information mediums.

The questionnaire was provided either in English or local language (one of the airports) based on key contact persons' advice. The questionnaire took around 25 minutes to complete. Prior to use, the questionnaire was pilot-tested prior among three professionals: a public health scholar, an infectious disease response consultant, and a safety manager at an airport.

Analyses

We analyzed results for each airport to get a sense of the volume and detail in the data and explore network visualizations. Using Excel, we analyzed baseline descriptives, computed mean (SD)s for continuous and ordinal (Likert-scale) questions, and percent scores for nominal questions. Findings were summarized per airport and per sector within one airport to allow inter-sector analysis and later within-sector analyses across airports. Using the network software Visone (Brandes & Wagner, 2004), we computed 2- and 1-mode data of the task involvement networks, and we computed contact networks and information flow graphs displayed on both degree (in and out) centrality and betweenness centrality. The degree centrality in this regard indicates the number of partners a partner either receives or sends information to. The betweenness centrality is calculated based on whether partners are on the shortest path between other partners in the network. In handbooks and scientific literature, this is one of the measures for coordination and control in networks (Hanneman & Riddle, 2005). For airport E, we decided not to compute the betweenness centrality because of the low response rate.

We drafted reports per airport to share and discuss in a 1-h session with the key contact person as a sense-making step. At this time also the allocation of partners over sectors was discussed. The within cases analysis was done by DdR and the findings were discussed with all authors. The cross-case analysis was based on comparative analyses of the individual findings of key contact interviews and questionnaire results. In an iterative process among individual and group analyses with all authors, we first descriptively compared findings across the five cases. We then formulated preliminary conclusions which were further studied to be confirmed, adjusted, or rejected based on the data.

RESULTS

Baseline

We selected five different European, designated airports of which the largest received over 50 million passengers per year and the smallest just over 1.5 million in 2019. Airports are numbered A–E. In Table 1, the baseline information of the five airports is shown. Numbers and affiliations have been presented in a way to maintain anonymity for the airports and key contact persons. An overview of all identified response partners per airport and sector including the abbreviations used to refer to these can be found in Appendix C in the supporting information.

Division of labor

Ex ante coordination

Response plans were in place at all airports based on the key contact interviews. In the questionnaire, each time between 2 and 5 partners at every airport stated that their tasks were predefined 'completely'. For airport A-C, these partners included one of the public health authorities. For airport E this included the airport medical service. The majority of partners, however, report that their pandemic tasks were predefined 'partly'. For all airports,

TABLE 1 Baseline characteristics for the participating airports.

Airport	A	B	C	D	E
Pax 2019	>50 million	20–30 million	15–20 million	5–7 million	1–2 million
% extra-EU air travelers	>50%–55%	25%–30%	25%–30%	-	45%–50%
Geographical distribution in Europe	West	South	West	North	East
Politico-administrative governance structure	Central	Central	Federal	Central	Central
Partners involved with COVID-19 response (n)	23	17	16	16	15
Response to questionnaire (*n* (%))	18 (78%)*	13 (70%)	14 (88%)	13 (81%)	8 (53%)**
Key contact person	MD at the PH authority; Airport control center	MD at the PH authority	MD at the PH authority; Airport manager	Health professional at the PH authority	Airport security manager
PH authorities	• Public health service (general) • PH infectious disease control	• Local department of the ministry of health • Regional competent authority	• Port health center • Public health center of the city	• National public health center: local- and national department	• Local epidemiologist • National public health center.
PH authority location	Outside the airport	At the airport & outside the airport	Outside the airport	Outside the airport	Outside the airport

*Corrected for one partner that was represented twice (total response $n = 19$).
**Corrected for two partners that were represented twice (total response $n = 10$).

more than half of the partners indicate that their tasks have not at all or only slightly changed since the start of the COVID-19 pandemic.

Ad hoc coordination

For new tasks occurring during the pandemic ad hoc coordination was done through different mechanisms.

At four of the five airports, dedicated crisis meetings were used to tune the COVID-19 response across partners, discussing both the task division and allocation of tasks. These crisis meetings were each time described as having been well-attended across partners. Partners most often involved in this joint allocation across airports were the airport management or directorate (4/5 airports), the local public health authority (4/5 airports), a regional or national public health authority (4/5 airports). The police or airport security were named for 3/5 airports. In the biggest airport (airport A), also the major airline was often involved. Overall, between 43 and 63 percent of partners indicated that joint allocation was one of the mechanisms to decide on new tasks. For the two smallest airports, all partners involved in the response were named by some other partner(s) in this joint decision-making. For the bigger airports around 70–80 percent of partners were at some point involved in the joint allocation. The highest number of partners involved on average in the allocation of new tasks can be seen in airport D, where each partner is named on average in 6(SD3.4) of the 19 response tasks.

Considerations for partners to be asked for a certain newly occurring task were estimated to be mainly based on good relations among partners (scoring on average >4.2 on a 5point Likert-scale for all airports) and because of particular knowledge and skills that a partner possesses to perform a response task (scored >4.1 on a 5-point Likert-scale for 4/5 airports). Relevant experience within an organization is considered one of the main drivers for four of the five airports. Airport B, in particular, considers available capacity as crucial to allocate a response task. All means for these drivers of selection are shown in Appendix D in the supporting information. Other ad hoc differentiation mechanism were 'by higher authorities' (between 54 percent (airport D)—88 percent (airport E)) and self-allocation of tasks (between 23 percent (airport D)—67 percent (airport A)).

What are the tasks?

For all airports, we see that there is involvement by at least one partner for every response task, although several tasks do not have a directly involved partner at a specific airport (Appendix E in the supporting information). An explanation could be that either this task has not or merely been performed, or the executing partner was not represented in the study. Next to the 19 predefined response tasks, participants named additional response tasks. These involved planning tasks, organization of repatriations, maintenance of COVID-19 rules, the set-up of

testing streets, handing out self-tests, statistics and data sharing. In addition, informing response partners at the airport was named by more than one participant.

Involvement in different response tasks

In the network graphs there are few clusters or subsets of partners that are involved with selective sets of response tasks. Partners at the different airports are involved in on average between 4.5 (airport D)—15.1 (airport E) of the 19 different response tasks, of which on average between 3.2 (airport C) and 8.4 (airport E) tasks directly. For direct involvement, we see for the smaller airports C–E a select set of partners that share responsibility for response tasks. In the two biggest airports (A and B), this set of actors that share responsibility for certain tasks is both absolutely and relatively bigger and less concentrated. It is remarkable that in the smallest airport E, all partners are involved in at least eight tasks if we include both direct and indirect involvement. At this airport, involvement is disseminated widely in the network. For the other airports, only a subset of partners that share involvement is seen, and all other partners being involved in fewer response tasks. An overview of the task allocation networks is shown in Figure 2.

Tasks connecting partners

Over all airports, there is one task involving by far the most direct and any involvement of response partners and that is task Q 'emergency and contingency planning for COVID-19'. Over all airports between 33 and 64 percent of partners is directly involved in this task, and between 50 and 100 percent in some way. We see different percentages of partners involved in response tasks, with remarkably high indirect involvement over tasks in airport A compared with airport C and D.

The integration of efforts

Why do partners contribute?

Amidst the considerations why airport partners contribute to the COVID-19 response, societal responsibility is scored highest across all airports, a mean of ≥4.6 on a 5-point Likert-scale. In all airports but airport D, also the habit of cooperation among partners is considered an important consideration (mean score ≥4.4). A third important consideration, except for airport C (3.7), is the business continuity of the airport (on average scored ≥4.5). Airport E scores remarkably high on the consideration for the organization's revenue (4.4). All scored considerations are shown in Appendix F in the supporting information.

The pre-COVID contact network

According to the collected data, all partners[2] were at least once a month in contact with one other partner in the network before the COVID-19 crisis. Based on the degree centrality, we see a nominal spread across partners at the airports. Most central nodes in the network vary. For airport A and B, these are the major airline, public health authority, instead of the airport directorate and red cross for airport C, or the emergency planning and local public health authority for airport D, and the ground-services, police and hospital for infectious diseases for airport E. Based on the betweenness centrality, we see for four airports one or two central partners. Airport B, however, is an exception as six partners have a similar and highest betweenness centrality in the network. The network graphs of the pre-COVID-19 contact networks are shown in Appendix G in the supporting information.

Crisis response scenarios

For the two response scenarios, we analyzed briefly the division of labor to be able to explain the information flow networks in these specific cases (Appendix H in the supporting information). An overview of the involvement in the scenarios, timing of involvement, mediums and the reasons for information flow are provided in Table 2.

For all airports, we see dense network graphs during the handling of scenario 1 and 2 in which, with some single exceptions, all local partners either send or receive information. The majority of ties in the networks are unconfirmed (Table 3). Lowest confirmation rates in the information networks are identified for the two largest airports. In scenario 1, a single partner is most central in airport B, C, and D. This central position is held by the local public health authorities, or the airport fire brigade (C). In airport A, the central position is shared between the flow passenger management and airport medical service. In scenario 2, a single central partner is seen at airport A, B, and D. At airport C the fire brigade and crisis center share their central position.

DISCUSSION

We reveal the characteristics of the ONs involved in the response to COVID-19 at five European airports. In the subsequent sections, we will first discuss the most dominant similarities among the airports, followed by the implications for the response to public health threats of the future.

Complex, trans-sectoral division of labor

What stood out in the task allocation in the response is the involvement of many partners across sectors in single

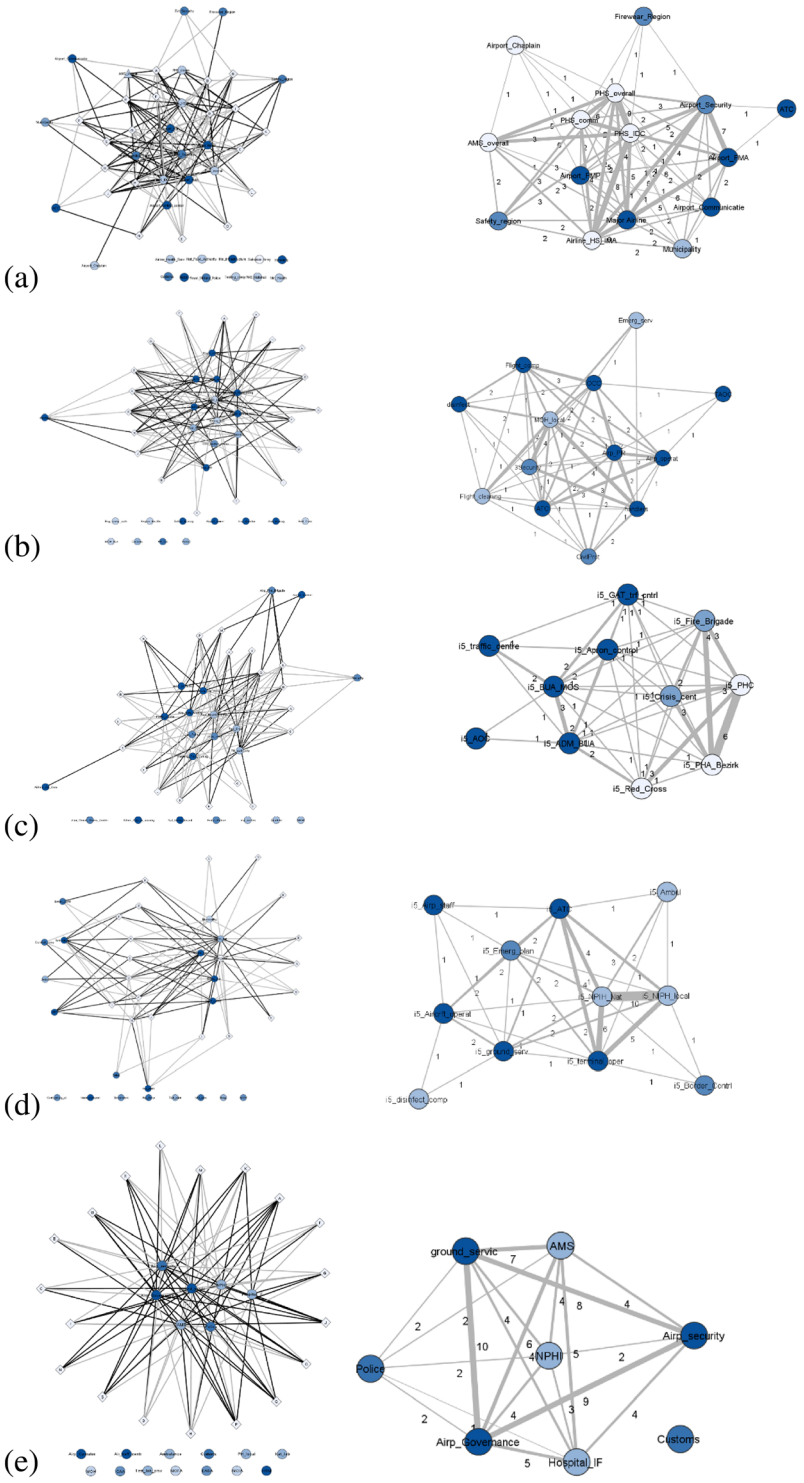

FIGURE 2 Per airport (a–e), on the left the 2-mode networks for involvement in response tasks; and on the right the 1-mode networks showing joint direct involvement in response tasks. 2-mode networks: Square nodes are response tasks, circled nodes are response organizations. Colors represent sectors. Black tie = direct involvement in response task; gray tie = indirect involvement in response task. 1-mode networks: Colors represent sectors. Ties represent joint direct involvement in response tasks, weighed per the number of tasks in which partners are jointly involved.

TABLE 2 baseline information in ranges for the two response scenarios.

	Scenario 1 (an approaching aircraft)	Scenario 2 (implementation of new entry-screening)
Familiarity with the case The case is recognized by…	62% (B)–90% (E) of partners.	74% (A) and 90% (E) of partners
Involvement in the case Surely or probably involved…	69% (D)–92% (C) of partners.	84% (A)–100% (B)
Timing of information Of those surely or probably involved is…	55% (B)–100% (C and D) within 1 h	23% (B)–69% (C) within 3 h
Timeliness of information	4.0[a] (SD1.2) (B)–4.7[a] (SD.5) (C)	4.1[a] (D and E)–4.6[a] (C)
Ex ante coordination tasks are predefined		
• 'Completely'… • 'Completely' + 'for the majority'…	31% (D)–70% (E). 69% (B)–90% (E)	8% (D)–31% (B) 31% (D)–70% (E)
Reasons for sending information		
• To tune actions with other partners • To report latest information • To coordinate activities • To provide advice • Don't know, because we are asked to	• 47% (A)–92% (B,C) • 32% (D)–71% (C) • 68% (A)–90% (E) • 32% (A)–41% (E) • 0%	• 58% (A)–86% (C) • 23% (D)–73% (E) • 42% (A)–90% (E) • 23% (D)–50% (E) • 0% (C, E)–15% (D)
Reasons for receiving information		
• To hear the latest information • To tune actions • To forward information • To receive coordination • To receive advice	• 32% (B)–70% (E) • 63% (A) and 90% (E) • 42% (A)–71% (C) • 21% (C)–85% (D) • 7% (C)–31% (B)	• 31% (B)–86% (C) • 46% (D)–86% (C) • 31% (D)–64% (C) • 21% (A)–80% (E) • 23% (D)–32% (A)
Mediums for the integration of efforts	Telephone (77%–100%) E-mail (46%–79%) Text messaging (28%–58%) Face-to-face (15%–60%) Video-calling (8%–62%) Digital platform (10%–57%) Dedicated radio channel (11%–30%)	E-mail (79%–100%) Telephone (70%–85%) Video calls (20%–79%) Face-to-face (31%–54%) Text messaging (8%–47%) Digital platform (0%–43%) Dedicated radio channel (0%–20%)

[a]On a 5-point Likert-scale.

response tasks. The task execution is complex due to trans-sectoral shared involvement in tasks, and the lack of clustering. Neither clusters of partners surrounding a (set of) task(s) nor clusters of tasks around a limited (set of) partner(s) are visible. These findings are in line with those presented by Kenis et al. (2017) in their network response study in the Netherlands. Using fictitious coronavirus scenarios, they likewise conclude that the expertise and efforts of many different partners are needed in reaching the public health goals (Kenis et al., 2017). The identified trans-sectoral division of labor at the different airports is mirrored in the integration of efforts, in both motivations and information provision, as we will show now.

A broadly shared trans-sectoral motivation to contribute to the response

Motivations to join the COVID-19 response on the interpersonal, organizational, and network levels are broadly shared across partners and sectors. In particular, the shared motivations on a network level are an important predictor of network effectiveness. These network-level motivations imply that organizations share a common purpose and in this sense indeed also try to work in the same direction (Carboni et al., 2019). The perceived societal responsibility at the airport overarches the interests of the air transport sector (continuation of traffic and trade) as well as the public health sector alone. Instead, it leads to the joint provision of different public services. The highly scored motivations on a network level furthermore correspond with the case presented in Kenis and Raab (2020), wherein a public ON motivation to contribute to dealing with the public problem was scored among the most important and organizational goals and monetary rewards among the lowest. Interestingly, the high motivation of the involved partners in the public-private network at the airports underpin previous findings on the importance of motivation and a common network goal.

Dense information flow networks with low confirmation rates

The complex division of labor in the ONs is also mirrored in the information flows. We saw dense information flow networks for both scenarios, despite high levels of predefined plans over the partners. These dense information

TABLE 3 Outcomes of the information flow networks in the two response scenarios.

Airport	A	B	C	D	E
Scenario 1					
Network density[a]	17%	23%	37%	19%	27%
Confirmed ties (ratio (%))	18/139 (13)	13/127 (10)	54/154 (35)	14/72 (19)	18/101 (18)
Highest degree (top 6) (absolute)	Airp_FMA (26) PHA_IDC (25) AMS (20) Region_Medical_Relief (20) Firewear_Region (19) Airport_Contrl_Center (18)	PH_Authority (28) Airp_PR (24) Airp_Operator (22) Emergency_Service (19) Flight_Company (19) Handlers (18)	Airp_Fire_Brigade (31) Airp_DM (26) Red_Cross (26) Airp_MOS (23) Crisis_Center (22) Region_PHA (21) Port_Health_Authority (20)	NPHI_Nat&Loc (20) Airp_Staff (14) Aircrft_Operat (14) Emerg_Planning (13) Ground_Service (13) Terminal_Operations (11)	NPHI (20) AMS (24) Ground_Service (20) Hospital_ID (19) Airp_Operator (13) Airp_Governance (13) Police (13)
Highest betweenness centrality (Standardized (>.05))	Airp_ FMA (.12) PHA_IDC (.10) AMS (.08) Regional_Medical_Relief (.07) Firewear_Region (.06)	PH_Authority (.21) Airp_PR (.12) Airp_Operator (.08) Flight_Company (.08) Emergency_Service (.07)	Airp_Fire_Brigade (.18) PFM (.11) Region_PHA (.10) Crisis_Center (.09) Airp_DM (.05)	NPHI_Nat&Loc (.25) Aircraft_Operator (.13) Ambulance (.08) Airport Staff (.07)	-
Scenario 2					
Network density[a]	16%	21%	27%	13%	23%
Confirmed ties (ratio (%))	14/131 (11)	15/116 (13)	24/113 (21)	10/48 (21)	22/88 (25)
Highest degree (top 6) (absolute)	AMS (21) PHA_Overall (21) PHA_IDC (21) Firewear_Region (17) Airp_Security (16) Major_Airline (16)	PHA (29) Airport operator (19) COV_Action_Group (17) Airp_PR (17) Emergency_Service (14) Airp_Security (14) Flight_Company (14)	Airp_MOS (23) Airp_Fire_Brigade (21) Feder_Police (20) Crisis_Center (16) Red_Cross (16) ATC (16)	NPHI_Nat&Loc (16) Emergency_Planning (13) Airp_Staff (13) Terminal_Operations (9) Border_Control (6) Emergency_Center (5) MOH (5) Municipality (5) Airp_Security (5)	NPHI (30) AMS (21) Ground_Service (18) Airp_Security (12) Airp_Governance (11) Airp_Operator (11)
Highest betweenness centrality (Standardized (>.05))	AMS (.16) PHA_Overall (.10) Firewear_Region (.09) Airport_Control_Center (.07) Major_Airline (.06) PHA_IDC (.06) Airp_FMP (.05)	PH_Authority (.35) Civil_Protection (.08) COV_Action_Group (.08) Emergency_Service (.08) Airp_Operator (.06)	Airp_Fire_Brigade (.12) Crisis_Center (.12) Airp_MOS (.07) Feder_Police (.06)	NPHI_Nat&Loc (0.13) Airp_Staff (.07) Emergency_Planning (.06) Border_Control (.06)	-

[a]In this density, the full pool of potential links is included, also for nonresponders in the network.

flow networks may be explainable in the light of the complex task allocation and the subsequently required continuous synchronization of actions among partners involved in the same tasks. However, we additionally see remarkably low confirmation rates for ties. In other words, many partners are sending or receiving information that is not acknowledged by the counter partner. The ONs handle a strategy of sending information rather to too many than to too few partners, while selective and targeted sending seems difficult. Contradictory, communication largely flows via various mediums that are fit for bilateral or selective information exchange, such as telephone, e-mail, and text messaging. As a result, it was a challenge to keep the overview of incoming information. Dealing with an information overload and the threat of scattered information among different mediums were named as challenges by several participants at different airports. An illustrative example is how airports occasionally say to use the dedicated radio system in place for aircraft emergencies just to stand out amidst the blur of information exchange. The dense information flow during response scenarios is clearly necessary but challenging to manage, as has also been recognized in previous research on COVID-19 response at points of entry (De Rooij et al., 2022).

Highly demanding positions to coordinate information flow

In these dense information networks, we see how both a high degree- and a high betweenness centrality are identified for public health authorities, floor managers, airport management and crisis- or emergency centers. If we assume that information flow tends to take the shortest path, this finding implies that a delay in information management easily leads to delays in the information provision. Most central partners according to the betweenness centrality are mainly the PH authority implying a coordinating position. A remarkable exception can be seen in airport C where the Fire Brigade is central in both scenarios, and in airport A where the airport medical service (AMS) is most central in the second scenario. It is hard to formulate a judgment on these positions. The PH authorities may seem the adequate partner to be in a coordinating position when dealing with a PH threat. However,

more important for these most central partners is that they are aware of their position and (are able to) act upon it.

Similar structures among airports

Lastly, summarizing the different differentiation and integration mechanisms, we find remarkably similar structures across the airports. In all airports, we see a central group of partners primarily involved with response tasks, with dense information ties between them. And although we see specific differences in the networks for the different airports, no clear structural distinction can be made based on the airport size, or the central vs. federal public health systems in which these airports have to function.

Implications for theory and practice

The similarity of the above-mentioned structures among the airports supports the idea that the type of threat is decisive for the specific network structure to respond to it. The character of these structures, on top of that, supports the conclusion made by Ansell et al. (2021) that the COVID-19 response, as an example of a so-called turbulent problem, cannot be dealt with based on standardized solutions but requires adaptive capacity. This perspective has several implications for both theory and practice of the airport crisis response.

We think applying organizational design thinking as suggested by Puranam et al. (2014) holds great promise to not only assess the functioning of networks but also help us in better facilitating them as we move forward in the use of this organizational form to tackle a variety of complex public problems. Especially in a crisis situations, where there is not much time and capacity for extended output or outcome measurements, their approach is helpful, because it provides a relatively simple framework to analyze the task and coordination requirements and act upon them. The assumption is then that if networks manage to solve these four problems well, they have a good chance to mount an effective response. However, more research on the functioning and structure of networks in crisis situations is necessary. Crises often require at least a temporary redesign of an existing network because the role of the airport in the protection of public services can change, as can the need for different actors or their roles. This is particularly true when the essence of the crisis moves from more straightforward to complex or even turbulent (Kenis et al., 2019). Next to our work, more empirical research is needed on crisis specific elements, their relationship with ON response optimization, and possibly enrichment of existing theories based on this. Our manuscript can be seen as the first stepping stone for follow-up research on this matter.

Also the identified complex trans-sectoral task allocation supports the idea that the use of ex ante coordination through crisis- and response plans appears to be difficult, as is described in both recent ON and public health literature (Kenis & Raab, 2020; De Rooij et al., 2022; Kenis et al., 2019). Instead, we need a governance layer during the response that is able to adapt the task division and allocation during the response. This layer needs to be self-reflective and in a position to govern 'robustly' through "the flexible adaptation, agile modification, and pragmatic redirection of governance solutions" (Ansell et al., 2021, p. 952). The four problems of organizing constitute a parsimonious framework that policy makers and professionals can use to continuously check the response with questions like: Has the situation changed, do we see new tasks emerge or in case of a specific situation, which tasks do we need to fulfill? Who can do these tasks or do we need to (temporarily) involve different organizations? What rewards need to be provided to organizations to safeguard their commitment to the collective outcome especially for those organizations that do not have that outcome in their core mission? What structure and processes do we need to put in place so the right information is with the right organization at the right time and we avoid information overload? These are relatively simple and clear questions -even though the answers might often not be simple- that can help structure the preparedness, learning and adjustment process before, during and after a crisis. It also can help to avoid becoming blind to new challenges which was very visible during the Covid-19 pandemic where networked systems primarily based on public health organizations were sometimes slow to adjust to the new and much broader needs (Berenschot, 2022; Moses, 2021). In addition, stating and responding to these questions can be trained in the preparedness phase to increase the governance competence and will form a structure without creating a relatively rigid response plan that might not work once a crisis occurs.

Safeguarding the integration of efforts

When preparing for the ad hoc division of labor, the consequences in the integration of efforts equally need to be safeguarded. This means that the information burden should be decreased through an intelligent and well-managed information system, as well as the reciprocity (has it reached the right partner?) in this exchange should be safeguarded. In additions, relations of trust and understanding among (potential) partners involved are needed (Ansell et al., 2021). Based on the results of the five included airports, these information systems should be greatly improved. Already promising are the pre-COVID contact networks in which the majority of partners were connected, and the broadly shared motivations among partners identified in this study. For motivation building,

Kenis and Raab (2020) stress how important it is to make intangible motivations explicit. We identified the societal responsibility as strongest motivation across airports and sectors. However, few airports were acquainted with feedback loops between the airport response and society. For the majority of airports, numbers such as passengers screened or cases identified were sent to higher authority levels and supported policy making on a national level, but the impact of results was not sent as feedback to the airports. A suggestion therefore could be to enhance this feedback loop between decision makers and affected sectors during long-lasting crises such as the COVID-19 pandemic, where in this case the interests of the air transport sector have been dramatically impacted.

Also—although not explicitly asked in the interviews or questionnaires—feedback loops of response outcomes to the airport users were not named as part of the monitoring while these can be supportive. Tuchen et al. (2020) reflect in light of the required flexibility in operations during the COVID-19 pandemic on how the 'user' perspective connects many impalpable system traits and even call it therefore "the most promising way to anticipate a wide variety of situations" (p. 4). A suggestion here would be to include also nonprofessional users of the airports in the trust- and relation building, such as travelers.

Implications for governance

Kenis et al. (2019) have suggested *the core-periphery governance* structure as most fit to deal with complex problems (defined as problems for which either the level of knowledge on dealing with it is low and/or the perception of the threat is high). In this structure, not one single partner is fit to coordinate alone, and therefore a group of partners has to cooperate closely in this function. Van den Oord et al. (2020) also find how a group of partners, part of different organizations function as the core group during the COVID-19 crisis in the port of Antwerp. This core-periphery governance structure can be practically handled during face-to-face crisis meetings that are described for different airports. Flexibility in timing and composition of these meetings together with any—if existing—other communication mediums in which a highly interactive exchange of information among several partners in possible seem the solution for the integration of effort especially in larger networks in complex response situations. These insights are also important for broader crisis management in public management as we increasingly face complex and unpredictable threats due to climate change, cyber-attacks, infectious diseases or energy shortages.

All of the above further confirm how COVID-19 response should be approached from a system's perspective integrating public health response within the ON of ongoing airport operations. In this perspective, the predefined list of response tasks that has been identified in the literature and that formed the basis for our ON analysis does not fit the airport operations of response. These literature and guidelines are written from a public health perspective and require specific local adaptation in the implementation in the airport setting. It is in this sense no surprise that additional response tasks were suggested by participants that pointed to the implementation and operationalization of public health tasks. Task division approached from a local operations perspective is therefore necessary.

Strengths and limitations

This study has several strengths and limitations. First of all, this is one of the first studies approaching the public health crisis response in the airport setting from a public administrative perspective. The five designated airports allow for a cross-case analysis and first attempts to hypothesize on generic lessons. Furthermore, data collection took place during the ongoing COVID-19 pandemic touching upon recent, realistic experiences. The use of scenarios to explore among others the networks of crisis response can be considered as both a strength and limitation. On the one hand, we acknowledge how our aims to grasp organizational response structures via scenarios are based on snap shots. The COVID-19 crisis has been variable, complex, multidimensional, and long-lasting, probably influencing our outcomes over time and based on this specific pandemic situation. On the other hand, scenarios are helpful by exploring a common process in these turbulent crisis situations. As such, the use of scenarios may be seen as a contribution for future crises research. The response rate was quite high regarding general surveys, but medium in relation to the relational data, potentially placing nonresponders unjustly in the edges of the networks, or not at all in the task allocation graphs. Also, we received some individual reactions that the questionnaire was experienced as too long and time-consuming, despite our aim to keep it as concise as possible.

The key contact provided a strong and trust-worthy position at the airports in selecting the right partners and explaining the specific airport situation. However, this key contact person may also potentially create bias as invitations were done based on the network of these contacts. This is important since the representation of organizations by individual participants is vulnerable for bias. In this light, we also have to name the 'two-table problem' for ON, as described by Kenis and Raab (2020), as individuals in organizations as well as entire organizations can have different roles. Also, the network boundaries in this sense are highly dependent on the position of this key contact person in the network and the predefined list of response tasks which were used as a selection criterium.

Defining the network boundaries appeared to be challenging. We used the precomposed list of tasks to select, primarily, local, or regional partners. It soon became clear

that for many airports many national partners were important in the daily response. Therefore, some of these were also included as participants. In the results, we indeed see that the boundaries for the network do not end with the airport location, or the region in which the airport is situated but include several partners not situated at the airport including national partners. The implication is that thinking primarily in local, regional, or national levels is shown to be artificial. Still, analyzing the entire system is not feasible in this study setting. Based on the limited number of additionally added partners by participants, we consider our results quite reliable. In future studies, however, the interaction between local, regional, and national levels may be an interesting subject of research.

Lastly, we analyzed network structures in order to learn for effectiveness of the response in the airport setting. However, effectiveness cannot be directly linked to the solutions of the four universal problems of organizing as analyzed in this study. We need to stress here that next to structure many other variables with regard to organizational capacity will influence the outcomes and impact, such as trained professionals, teams, funding, and sufficient hard ware and communication capacities—to name a few. We analyzed the four fundamental problems of organizing to create a basis for effective response and therefore focused on cross-case analysis and generic lessons.

CONCLUSION

This is one of the first studies analyzing public health response at airports form a public administrative perspective. We used the COVID-19 pandemic as a recent and realistic situation to analyze the response in practice-based scenarios. The analyses revealed a complex and multi-sectoral division of labor requiring high burdens for the integration of efforts. We stress how essential it is to integrate these characteristics while preparing effective pandemic response. COVID-19 response in the airport setting in particular needs governance from a meta-perspective that is able to reflect on and adapt to the tasks defined and allocated among partners. Consequently, coordination and communication structures should also be fit to deal with these adaptations. It is worrisome that public health response in the airport setting has been described in the pre-COVID literature from a mainly technical perspective, while effective public administration and governance clearly affects the response and should be factored in as such. Expansion of scientific knowledge in this overlapping field of public health and—administration, and in particular focused on the collaborative, multi-sectoral and flexible approach, is needed to further enhance preparedness for the next known or unknown threat at airports.

ENDNOTES

[1] 'Designated points of entry' are those points of entry selected in by and in a country that are at highest risk for dealing with public health emergencies of international concern, and therefore are bound to have implemented minimum core capacity requirements (as stated in the International Health Regulations).

[2] Except one partner at airport A. This single, unconnected partner did not respond to the questionnaire and therefore had not the opportunity to explain their position in the network.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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