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Structural integration and performance of inter-sectoral public health-related policy networks: An analysis across policy phases

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ABSTRACT

Background: Inter-sectoral policy networks may be effective in addressing environmental determinants of health with interventions. However, contradictory results are reported on relations between structural network characteristics (i.e., composition and integration) and network performance, such as addressing environmental determinants of health. This study examines these relations in different phases of the policy process.
Methods: A multiple-case study was performed on four public health-related policy networks. Using a snowball method among network actors, overall and sub-networks per policy phase were identified and the policy sector of each actor was assigned. To operationalise the outcome variable, interventions were classified by the proportion of environmental determinants they addressed.
Results: In the overall networks, no relation was found between structural network characteristics and network performance. In most effective cases, the policy development sub-networks were characterised by integration with less interrelations between actors (low cohesion), more equally distributed distances between the actors (low closeness centralisation), and horizontal integration in inter-sectoral cliques. The most effective case had non-public health central actors with less connections in all sub-networks.
Conclusion: The results suggest that, to address environmental determinants of health, sub-networks should be inter-sectorally composed in the policy development rather than in the intervention development and implementation phases, and that policy development actors should have the opportunity to connect with other actors, without strong direction from a central actor.

1. Introduction

In high-income countries, half of the burden of disease is attributable to unhealthy behaviours, such as alcohol abuse, physical inactivity, and unhealthy diets [1]. Health-related behaviours are strongly influenced by environmental factors. These environmental determinants are situated in the physical (e.g., housing), social (e.g., social networks), economic (e.g., income distribution), and political (e.g., laws on alcohol distribution) environments [2]. Therefore, to be effective, interventions that promote healthy behaviours should – next to personal determinants, such as motivation – also address the environmental determinants. In practice, however, health promoting interventions are mainly aimed at changing personal determinants [3]. This is attributed to the fact that most of the environmental determinants are situated outside the sphere of influence of the public health sector [4,5] This illustrates the necessity of involving non-public health actors in public health policy [4,6–8]. As a result, connections between actors from different policy sectors emerge [9] and inter-sectoral policy networks arise. An important indicator for the performance of such public health-related networks is the extent to which they succeed in addressing environmental determinants of health behaviours.

Characteristic for inter-sectoral policy networks is that resources from different policy sectors are utilised. Such resource pooling is about the willingness of actors to share resources such as authority, knowledge, and financial means [10]. However, network actors are (in principle) autonomous in deciding whether to employ their resources in favour of the network or not [11]. Such complexity may hamper network performance. Network composition is thus an important characteristic of the network structure. However, the relation between such structural network characteristics and network performance in terms of the environmental determinants addressed has never been an explicit object of study.

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Apart from the composition of the network, other aspects of the network structure that are assumed to impact network performance are related to network integration mechanisms. Network integration refers to the process of creating and maintaining a common structure between independent policy actors for the purpose of coordinating their interdependent contributions to achieve a common policy objective [12]. Hence, integration mechanisms focus on the extent to which network actors are coordinated by a central actor (i.e., centralisation) [13] and the level of cohesion between the network actors (i.e., density). Centralisation facilitates coordination, and thus integration of the network as it represents the power and control levels in a network and thus the hierarchy structure [14]. Centralisation may be crucial to encourage otherwise autonomous actors to act in favour of system-level goals [13,15]. This is in contrast to decentralised, horizontally integrated networks. That is, if such networks include a large number of organisations, coordination by a central actor alone can be too complex for network performance to occur [16]. Density, as a measure of cohesion, informs about the speed at which information can circulate in the network. High density levels may enhance communication and collaboration among actors and thus result in better network performance [17]. However, too high density levels may also negatively impact network performance [13] because of the limits to the number of connection an actor can handle. In large and complex networks, network performance may still occur if small groups or cliques of actors exist that are connected to each other by one or more shared actors (i.e., clique overlap) [18]. Information can then flow from clique to clique, warranting coordination and collaboration.

These contradictory (theoretical) insights in the relation between structural integration mechanisms and network performance, e.g., centrally [13] versus horizontally integrated [18] and dense [13] versus not dense [17], might be due to the different types of networks studied (e.g. inter- and intra-organisational networks), the purpose of these networks (e.g., service delivery networks versus information diffusion networks), or different sizes of the networks. Contradictory results could also occur depending on the policy phase in which the data collection took place. Although policy processes evolve in a dynamic rather than an incremental way, it is still legitimate – and may be helpfull – to distinguish different policy phases based on the specific tasks to be accomplished [19]. So far, most network studies either focus, at least implicitly, on the policy implementation phase, or do not explicitly distinguish between policy phases. This means that the actors surveyed might in fact refer to different phases of the policy process, which may also be an explanation for contradictory study results. Therefore, we argue that the relation between structural integration mechanisms and network performance might not be stable throughout the policy process, but may vary for the different phases. This implies that different types and levels of integration may exist for different sub-networks in the different phases leading to high network performance.

The aim of this study was *to examine the relations between structural network characteristics (i.e., network composition and network integration mechanisms) in different phases of the policy process and network performance in terms of the proportion of environmental determinants of health addressed.*

2. Methods

2.1. Research design and case selection

A multiple-case study was performed on four policy networks of the *Gezonde Slagkracht* program in the Netherlands (Decisive Action for Health; 2009–2014) [20]. This program was initiated by the Ministry of Health, Welfare and Sport to give municipalities the opportunity (in terms of subsidiary budgets and professional support) to experiment with building inter-sectoral policy networks. Municipalities were obliged to appoint a network leader. In accordance with the program's objectives, the aim of the inter-sectoral networks was to develop and implement integrated public health policies on the prevention of overweight, alcohol and drugs abuse. Since differences may occur due to the central health theme, we selected two cases dealing with overweight (cases A and B) and two with alcohol abuse (cases C and D). Other selection criteria were the variance in network performance in terms of environmental determinants addressed by the interventions that had actually been implemented by each case, the expected size of the networks and the geographical area of the cases. Box 1 provides information on the cases based on a previous study [21].

Box 1: Cases.

The overweight projects A and B were expected to be relatively similar in size and in geographical area. Both project leaders were civil servants working in a non-public health sector. The projects differed in their approach. Case A had characteristics of a top-down approach involving different municipal policy departments and other organisations, whereas B had a bottom-up approach, involving facilitation of problems questioned by citizens. The overall goal of case A was to increase the attention for healthy foods and a healthy diet among parents, their children and among citizens with low social status. Case B aimed to support citizens (especially children and youth, unemployed citizens, and citizens with low social status) in specific neighbourhoods to live a healthy life with, e.g., case finding and facilitation strategies.

The alcohol cases in the *Gezonde Slagkracht* programme were mainly regional networks, in which municipalities still developed and implemented their own policies. Therefore, we chose one municipality from a large regional network (case C), that was comparable to the only single municipality alcohol case (case D). Both projects (C and D) had enthusiastic non-public health project leaders. However, the leader of D was responsible only for this alcohol project, whereas the leader of C had more tasks; this latter project leader received support from the regional project. The overall goal of projects C and D was to reduce alcohol usage amongst youngsters resulting in a decline of the negative effects of alcohol use with, e.g., regulation and enforcement strategies.

2.2. Data collection on central concepts

The network data were collected in 2013. First, a network survey was conducted among the network leaders of the four cases, asking with whom they had contact in the context of the *Gezonde Slagkracht* program. Respondents could choose from a list with actors they had indicated as contacts in a previous survey to identify their ego networks [22], while they were additionally allowed to enumerate other actors. Using a snowball method, we approached the contacts of the leaders to identify in turn their contacts in the context of the *Gezonde Slagkracht* program. Generally, three rounds were enough to reach data saturation. Response rates varied from 73% to 83%.

Network actors first had to name their work place. Next, they were asked to select all phases of the policy process they were currently or had previously been involved in. These phases can be operationalized as follows. Policy development phase: setting-up and planning the case, e.g., involved in the problem analysis and the formulation of program objectives. Development of interventions phase: building or selecting intervention components, e.g., involved in choosing intervention strategies and in the planning

of their execution. Implementation of interventions phase: carrying out the intervention, e.g., involved in the actual provision of interventions for the target group.

Based on their work place, we assigned network actors to the policy sector they belonged to (e.g., education, public health, spatial planning). Inter-sectoral composition of the networks was operationalized as the number of actors outside the public health sector relative to the total number of actors in the network. Based on the actors' self-reported involvement, we also identified the size and inter-sectoral composition of the sub-networks per policy phase.

Network performance, was assessed in a separate survey among implementation professionals only. These professionals were asked to report the targeted behavioural determinants (i.e., either personal or belonging to the social, physical, economic or political environment) separately for each of the interventions implemented. The average response rate was 68%. The variable addressing environmental determinants of health was operationalised as the number of environmental determinants of health relative to the total number of determinants addressed.

2.3. Integration mechanisms

Using UCINET [23], as a first step, we symmetrised the data to examine the overall communication structures in both the networks and the sub-networks, and calculated density, centralisation and number of cliques. In short, density indicates the general level of cohesion in a network or the extent to which all network actors are linked, centralisation is the extent to which the network is organised around any particular focal point [14,24], and cliques are subgraphs in a group of three or more actors that are all connected to each other. Our network analysis also identified the central actors in the networks. The different structural network characteristics are further explained in Box 2,

The second step in our analysis was an exploratory comparison of the relation between structural network characteristics and network performance in term of determinants addressed with the interventions implemented. For that, we first ordered the cases by performance level (i.e. proportion of environmental determinants addressed). Next, we made a comparison of the structural network characteristics in order to identify patterns that could explain (a) the rank order of the individual cases from least effective to most effective, and (b) the difference between the two least effective cases and the two most effective cases.

Box 2: Integration measures.

Density indicates the general level of cohesion in a network or the extent to which all network actors are linked, and informs about the potential speed at which information can circulate in the network. We calculated density as the actual number of connections relative to the maximum possible number of connections within a (sub-)network (20). A value of 0 indicates an empty graph and a value of 1 a completely connected graph in which each actor has ties with all other actors in the network. Next, we calculated the level of ***centralisation***, i.e., the extent to which the network is organised around any particular focal point (11; 20), with three measures: mean degree, network degree and network closeness. We calculated the *mean degree centrality* as the average number of ties the actors in the (sub-)network have. The larger the value together with a high standard deviation, the more central a single actor or a small group of actors and the less central the remaining actors are (12). *Network degree centralisation* was calculated as the variability of degree centralities over all the network actors (12). A value of 100% means that the network is a complete star graph, indicating a maximum hierarchy of one actor. The *network closeness centralisation* is the variability of the distance of the actors between each other, indicating how quickly an actor can interact with all others. Minimum value of 0% indicates that the lengths of the paths (geodesics) are all equal, e.g. in a complete or circle graph, and maximum value of 100% indicates that the connections are unequally distributed over the network (12).

The ***central actor*** is the most influential actor in the network; the actor with the highest closeness levels (28). Its degree represents the number of direct connections of the central actor and its norm degree the number of connections relative to the maximum possible number of connections in the network.

Finally, we calculated ***cliques***, which are complete subgraphs in a group of three or more actors. All actors in a clique are connected to each other. Cliques are a type of cohesive subgroup, i.e., "*subsets of actors among whom there are relatively strong, direct, intense, frequent, or positive ties*" (12 p. 249). We calculated cliques with different minimum numbers of actors, starting from three and increasing to five when there were many cliques with a lower clique size.

3. Results

3.1. Overall policy networks

The size of the policy networks varied between 14 and 30 actors (Table 1). The networks on the theme of overweight (case A and B) typically included actors from public health as well as from the welfare, social support, sports and education sectors. The networks on the theme of alcohol were characterised by a combination of actors from public health as well as the sports and the safety and enforcement sectors (case C and D). The inter-sectoral composition of the networks varied between 0.64% (case C) and 93% (case A).

3.2. Sub-networks per policy phase

The sub-networks related to policy development were the smallest (4–13 actors), while those related to policy implementation were the largest (13–28 actors; Table 1). For all cases, the sub-networks per policy phase included less sectors than the overall networks. In three cases (A, B and D), the policy development sub-networks less inter-sectorally composed than the other sub-networks, while in all four cases, the policy implementation sub-networks were the most inter-sectorally composed.

3.3. Network performance

The number of interventions implemented ranged from 5 (case D) to 30 (case C) (Table 1). Except for case D, the number of personal determinants addressed exceeded the number of each of the environmental determinants addressed. Network performance was lowest in case A, with 29% of all determinants addressed being environmental, and highest in case D, with 71% of all determinants addressed being environmental.

3.4. Relations between structural network characteristics and network performance

Our exploratory comparison of the overall networks did not reveal any pattern in the structural network characteristics that could explain the differences in performance between the cases, but we did find such patterns for the sub-networks.

Patterns that could explain the rank order of the cases from least effective to most effective were found in de policy development sub-networks (dark grey-shaded figures in Table 2). The more effective the case, the higher was the proportion of network actors incorporated in these sub-networks. In addition, in more effec-

Table 1
Network composition per case and per policy phase, and network performance.

			Network composition														Network performance							
Case	Theme	(Sub-)Network per policy phase	Number of actors	Public Health	Welfare	Social Support *	Sports	Culture and Recreation	Education	Social Affairs and employment	Safety and Retention	Private Sector Organizations	Consultancy/Science/Research	Community	Other	Level of non-public health actors in the network	No. of personal determinants	No. of social environment	No. of economic environment	No. of physical environment	No. of political environment	No. of non-personal determinants in interventions	Total no. of determinants in interventions	Proportion environmental determinants
A	Overweight	Overall	30	2	5	1	2	1	9	1	0	7	2	0	0	0.93	5	1	0	1	0	2	7	0.29
		Pol. Dev.	4	2	0	1	1	0	0	0	0	0	0	0	0	0.50								
		Int. Dev.	21	2	4	1	1	1	8	0	0	2	2	0	0	0.90								
		Int. Impl.	28	2	4	1	2	1	9	1	0	6	2	0	0	0.93								
B	Overweight	Overall	23	3	4	2	3	1	2	0	1	1	1	3	2	0.87	11	0	1	4	1	6	17	0.35
		Pol. Dev.	5	2	0	1	0	0	1	0	0	0	1	0	0	0.60								
		Int. Dev.	6	2	1	1	0	0	1	0	0	0	1	0	0	0.67								
		Int. Impl.	22	3	4	1	3	1	2	0	1	1	1	3	2	0.86								
C	Alcohol	Overall	14	5	0	0	4	0	1	0	2	0	0	0	2	0.64	34	24	6	1	6	37	71	0.52
		Pol. Dev.	8	4	0	0	1	0	0	0	2	0	0	0	1	0.50								
		Int. Dev.	9	5	0	0	2	0	0	0	2	0	0	0	0	0.38								
		Int. Impl.	13	5	0	0	4	0	1	0	2	0	0	0	0	0.62								
D	Alcohol	Overall	26	5	3	0	2	0	4	1	5	1	1	1	3	0.81	2	3	0	0	2	5	7	0.71
		Pol. Dev.	13	3	3	0	1	0	0	1	2	0	1	0	2	0.77								
		Int. Dev.	20	4	3	0	1	0	1	1	5	1	1	0	3	0.80								
		Int. Impl.	26	5	3	0	2	0	4	1	5	1	1	1	3	0.81								

Notes * Dutch Social Support Act.
Pol. = Policy, Dev. = Development, Int. = Interventions, Impl. = Implementation.

tive cases these sub-networks had lower density levels (indicating less interrelations between all actors), lower degree centralisation (indicating the absence of a completely central actor), lower closeness centralisation (indicating more equal distances between actors), and lower norm degree for the central actor (indicating less direct connections of the central actor with other actors in the network). Finally, in more effective cases the policy development sub-networks encompassed a higher number of inter-sectoral composed cliques with substantial clique overlap (indicating more horizontal network integration).

Patterns that could explain the difference between the least effective and the most effective cases were additionally seen in the intervention development sub-networks (light gray-shaded figures in Table 2). In the more effective cases, these sub-networks had lower degree centralisation, lower closeness centralisation and lower norm degrees for the central actor, indicating that these sub-networks had in part similar structural characteristics as the policy development sub-networks.

4. Discussion

4.1. Summary of results

This network analysis examined the relation between structural network characteristics (i.e. network composition and network integration) and network performance in terms of environmental determinants of health addressed by interventions implemented in these networks. We found no pattern in the structural network characteristics of the overall policy networks that could explain differences in performance between cases, but we did find such a pattern for – especially – the sub-network in the policy development phase. In more effective cases, the policy development sub-networks incorporated more network actors, had lower density levels (less interrelations between all actors), lower degree centralisation (not one completely central actor), lower closeness centralisation (more equal distances between actors), lower norm degree for the central actor (less direct connections of the central actor with other actors), and a higher number of inter-sectoral composed cliques (indicating horizontal network integration).

4.2. Limitations

The study has some limitations. First, since we studied only four cases we cannot draw quantitative verifiable conclusions. However, this qualitative comparison revealed patterns that we interpret in terms of propositions intended for further research. Further studies may include large-scale surveys that also examine non-structural network characteristics, e.g. network management [25], trust [26], financial resources [15], and contextual factors [16,24]. In-depth qualitative inquiries may additionally be employed to identify the specific micro processes, e.g., within sub-networks per policy phase, that may contribute to the performance of a policy network as a whole [27].

Second, the overweight cases were less effective in addressing environmental determinants of health and the alcohol cases were more effective; this might suggest that the health theme is a confounder in the relations studied. In turn, this might imply that the level of network performance in terms of addressing environmental determinants of health may be influenced by a network being related to overweight or to alcohol. However, within the cases that address the same health theme similar patterns were found, indicating that our results are not biased by the specific health themes chosen.

Third, for the outcome variable of case C we had to use data at the level of the larger regional network that case C is part of. This might distort the results, since the outcome variable also contains data from other municipalities of the regional case. However, case C was comparable to the only single municipality alcohol case (case D) within the *Gezonde Slagkracht* program. Furthermore, the Regional Public Health Services offered a range of interventions the

Table 2
Network performance and network structure mechanisms of public health-related policy networks.

Cases			**A**	**B**	**C**	**D**
Health theme			Overweight	Overweight	Alcohol	Alcohol
Network performance						
Proportion of environmental determinants addressed			0.29	0.35	0.52	0.71
Number of interventions implemented			5	13	30	5
Network composition						
Network size		**Overall**	**30**	**23**	**14**	**26**
(proportion of overall network; %)		Pol. Dev. Ph.	4 (13)	5 (28)	8 (57)	13 (50)
		Interv. Dev. Ph.	21 (70)	6 (26)	9 (64)	20 (77)
		Interv. Impl. Ph.	28 (93)	22 (96)	13 (93)	26 (100)
Level of inter-sectorality (%)		**Overall**	**93**	**87**	**64**	**81**
		Pol. Dev. Ph.	50	60	50	77
		Interv. Dev. Ph.	90	67	38	80
		Interv. Impl. Ph.	93	86	62	81
Integration measures						
Density (SD)		**Overall**	**0.22 (0.41)**	**0.30 (0.46)**	**0.42 (0.49)**	**0.38 (0.49)**
		Pol. Dev. Ph.	0.67 (0.47)	0.70 (0.46)	0.39 (0.49)	0.28 (0.45)
		Interv. Dev. Ph.	0.17 (0.37)	0.53 (0.50)	0.47 (0.50)	0.25 (0.43)
		Interv. Impl. Ph.	0.23 (NA)	0.26 (0.44)	0.46 (0.50)	0.32 (0.47)
Centralization	Mean degree (SD)	**Overall**	**6.27 (5.59)**	**6.61 (4.90)**	**5.43 (3.06)**	**9.62 (6.05)**
		Pol. Dev. Ph.	2.00 (0.71)	2.80 (0.98)	2.75 (1.56)	3.39 (2.00)
		Interv. Dev. Ph.	3.33 (3.62)	2.67 (1.25)	3.78 (1.47)	4.70 (2.93)
		Interv. Impl. Ph.	6.21 (5.27)	5.55 (4.30)	5.54 (2.74)	8.08 (5.02)
	Network degree Centralisation (%)	**Overall**	**76.60**	**56.71**	**58.97**	**58.00**
		Pol. Dev. Ph.	66.67	50.00	42.86	35.61
		Interv. Dev. Ph.	81.05	70.00	35.71	42.69
		Interv. Impl. Ph.	74.93	60.00	53.79	56.00
	Network closeness Centralisation (%)	**Overall**	**81.08**	**55.78**	**65.50**	**62.92**
		Pol. Dev. Ph.	75.00	60.00	42.50	32.08
		Interv. Dev. Ph.	84.63	79.46	34.80	39.97
		Interv. Impl. Ph.	79.69	59.61	60.66	57.05
Central actor	Sector	**Overall**	**PH**	**PH**	**SPORTS**	**SAE**
		Pol. Dev. Ph.	PH	SSA	PH	SAE
		Interv. Dev. Ph.	PH	PH	SPORTS & PH	SAE
		Interv. Impl. Ph.	PH	PH	SPORTS	WELFARE
	Degree (Nrm Degree, %)	**Overall**	**27.00 (93.10)**	**18.00 (81.82)**	**12.00 (92.31)**	**23.00 (92.00)**
		Pol. Dev. Ph.	3.00 (100.00)	4.00 (100.00)	5.00 (71.43)	7.00 (58.33)
		Interv. Dev. Ph.	18.00 (90.00)	5.00 (100.00)	6.00 (75.00)	12.00 (63.16)
		Interv. Impl. Ph.	25.00 (92.59)	17.00 (80.95)	11.00 (91.67)	21.00 (84.00)
Clique measures						
Number of cliques, levels of inter-sectorality of cliques (%) and clique overlap[a] per subnetwork (%)		**Overall**	**N[5]=8**	**N[5]=15**	**N[5]=2**	**N[5]=22**
		Intersect. level	**67 ≤ 81 ≥ 88**	**67 ≤ 74 ≥ 80**	**33 ≤ 37 ≥ 40**	**60 ≤ 75 ≥ 100**
		Clique overlap	**64%**	**20%**	**100%**	**24%**
		Policy Dev. Ph.	N[3]=1	N[3]=1	N[3]=4	N[3]=7
		Intersect. level	33	50	33 ≤ 50 ≥ 67	67 ≤ 78 ≥ 100
		Clique overlap	-	-	60%	38%
		Interv. Dev. Ph.	N[3]=13	N[3]=3	N[3]=8	N[4]=4
		Intersect. level	33 ≤ 60 ≥ 75	67	33 ≤ 42 ≥ 67	75
		Clique overlap	8%	60%	43%	50%
		Interv. Impl. Ph.	N[4]=10	N[4]=18	N[4]=7	N[5]=14
		Intersect. level	50 ≤ 70 ≥ 88	50 ≤ 79 ≥ 100	40 ≤ 49 ≥ 50	40 ≤ 66 ≥ 80
		Clique overlap	39%	21%	20%	29%

Notes
Sub-networks: Pol. Dev. Ph. = policy development phase, Interv. Dev. Ph. = intervention development phase, Interv. Impl. Phs = intervention implementation
PH = Public Health, SSA = Dutch Social Support Act (in Dutch: Wet Maatschappelijke Ondersteuning), SAE = Social Affairs and Employment
[a] UCINET was used to calculate the number of actors in the clique so that at least 3 cliques per sub-network exist (otherwise there would be too many sub-networks with just 1 clique) and the level of clique overlap can be calculated.
N = number of cliques, # min. x actors in the cliques, - means that there was only one clique in this sub-network. Since cases A and B only had one clique with three actors in the policy development sub-netwerks, clique overlap could not be calculated.

municipalities could choose from. During conversations with network actors we noticed that case C seemed to have implemented a relatively broad set of interventions, indicating that this seems to be an average case within this regional case.

4.3. Interpretation of the findings

We found that inter-sectorality in policy networks – especially in policy development – increases the possibility to gain

network performance in terms of addressing environmental determinants of health. An explanation as to why inter-sectorality may be so important in the policy development phase can be found in the literature on resource pooling and policy implementation. For example, other sector actors have the knowledge and the policy instruments to address specific environmental determinants of health, e.g., the police on enforcement of under-age drinking, the department of Spatial Planning on planning of the surroundings. Introducing these non-public health actors in the intervention phases when the policies have been developed seems to be too late to address environmental determinants of health. This might be due to the lack of possibilities for the non-public health actors to have actual influence on the policy goals. All actors have their own definition of the problem [28] and whether actors contribute to a network is often motivated by self-interest. Actors are willing to do so when they have the opportunity to safeguard their own interests and thus will ask themselves whether network involvement benefits their agency [24]. According to policy implementation literature "*implementation should not be divorced from policy*", since "*there is no point in having good ideas if they cannot be carried out*" [29 p. 143]. Closing the gap between policy development and (inter-sectoral) implementation means that a policy theory can be formulated with respect to its execution and thus can anticipate contextual factors in the real world. This makes policy goals more realistic so that they can be realised more successfully. The policy development sub-network should therefore be inter-sectorally composed. Further research should test proposition 1 in a larger study.

Proposition 1. *To gain network performance in terms of addressing environmental determinants of health, sub-networks should be inter-sectorally composed in the phase of policy development rather than in the phases of intervention development and intervention implementation.*

Furthermore, we found that horizontal integration of policy development sub-networks increased the possibilities to address environmental determinants of health. In previous studies, mainly centrally integrated networks were related to network performance. For example, a study on intra-organisational policy networks in the education sector [17] found that heterogeneous, i.e., inter-sectoral, networks should be centrally and densely integrated to be effective in terms of innovation and efficiency. Provan and Milward [13] studied such structural mechanisms of inter-organisational service delivery networks in the mental health sector, and concluded that networks that are coordinated and integrated centrally are likely to be more effective than dense, cohesive networks. They argue that very dense networks are likely to be unnecessarily complex and inefficient. These relations are measured in networks as wholes, and in sectors other than the public health. We measured these relations in sub-networks per policy phase; this might explain why we found an opposite association, i.e., between horizontal integration (in which small inter-sectoral subsets of actors coordinate the policy development sub-network) and network performance. This result (more or less) fits the conclusion of Provan and Sebastian [18] who studied network performance by examining inter-organisational ties among small groups or cliques of organisations within a large network (i.e., horizontal coordination). They found that network effectiveness occurred when these different cliques were connected with each other by the same actors (i.e., clique overlap) and information can flow from clique to clique. In our most effective case, the formal case leader was part of almost all cliques. This most central actor from the department of Social Affairs and Employment made information flow possible between the cliques. Based on Larson [30] and Uzzi [31], Provan and Sebastian [18] mention that such integration results in clique members that learn from each other, which minimises their transaction costs and establishes working relationships based on cooperation and trust. Furthermore, we think that the absence of network centrality creates opportunities for non-public health actors to find connections with public health issues and safeguard their own interests within the public health-related policy. Further research should test proposition 2 in a larger study.

Proposition 2. *To gain network performance in terms of addressing environmental determinants of health, sub-networks in the policy development phase should be horizontally rather than centrally integrated.*

4.4. Implications for research

Whereas Provan and Sebastian [18] start by analysing network structure in a more micro-analytic way by studying overlapping cliques, we add another micro-analytic focus by studying sub-networks per phase of the policy process. When studying only overall networks, we would not have found an explanation in structural network characteristics for differences in performance between least effective and most effective cases. Analysing sub-networks over time in and for different policy phases sheds new light on the relation between structural network characteristics and network performance.

5. Conclusion

The present study suggests that the performance of inter-sectoral public health-related policy networks in terms of addressing environmental determinants of health may depend on both the composition and levels of integration of – especially – the sub-network in the policy development phase. Inter-sectoral actors in this sub-network should have the opportunity to connect with other actors through horizontal integration of the network without strong direction from one (or a few) central actors. When analysing network performance by studying structural integration mechanisms, it is recommended to analyse sub-networks related to different phases of the policy process.

Conflicts of interest

None declared

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