Interdisciplinary Cooperation in Health Promotion for University Students

Structures, mechanisms, and practice

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Für meine Frau Šarūnė.

Für meinen Sohn Korbinian und meine Töchter Philomena und Ophelia.

Für meine Geschwister, meine Eltern und Großeltern.

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ABSTRACT

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Introduction: Interdisciplinary cooperation among actors is considered a key success factor in health-promoting universities. However, there is a research gap regarding in-depth information about structural characteristics and the conditions of health-promoting networks at universities. In this thesis, cooperative relations among actors were investigated in a German health-promoting university. The aim was to explore the structure of interdisciplinary cooperation and to explain the mechanisms of interdisciplinary cooperation.

Methods: Social network analysis was performed, and network metrics as well as exponential random graph models were calculated. Network data were collected in the winter semester of 2019 using a standardized questionnaire via face-to-face interviews with a total of 33 university actors. Network boundaries were specified in a multifaceted snowball sampling process.

Results: The investigated network shows a flat, non-hierarchical structure. Key actors in the context of student health at university were identified. The likelihood of cooperation between actors involved in the network is determined by micro-structural antecedents and attributive factors.

Conclusion: The present thesis increases the knowledge about organizational structures and processes unfolding in interdisciplinary cooperation among actors of health-promoting universities. The results can be used to further develop the present network and also provide starting points for network development at other universities.

Keywords: organizational network analysis, interdisciplinary cooperation, health-promoting universities, university students' health

ZUSAMMENFASSUNG

Interdisziplinäre Zusammenarbeit in der Gesundheitsförderung für Studierende

Strukturen, Mechanismen und Praxis

Einführung: Interdisziplinäre Zusammenarbeit von Akteuren gilt als ein zentraler Erfolgsfaktor gesundheitsfördernder Hochschulen. Es besteht jedoch eine Forschungslücke hinsichtlich Strukturen und deren Bedingungen mit Blick auf gesundheitsfördernde Netzwerke an Universitäten. In dieser Dissertation wurden die Kooperationsbeziehungen zwischen Akteuren einer deutschen gesundheitsfördernden Hochschule untersucht. Ziel war es, die Struktur interdisziplinärer Zusammenarbeit zu erforschen und zugrundeliegende Mechanismen zu erklären.

Methoden: Es wurde eine soziale Netzwerkanalyse durchgeführt, in deren Rahmen Netzwerkkennzahlen und exponentielle Zufallsgraphenmodelle berechnet wurden. Die Netzwerkdaten wurden im Wintersemester 2019/2020 mittels eines standardisierten Fragebogens im Zuge persönlicher Interviews mit insgesamt 33 Hochschulakteuren gesammelt. Die Netzwerkgrenzziehung erfolgte durch ein mehrstufiges Schneeballverfahren.

Ergebnisse: Das untersuchte Netzwerk weist eine flache, nicht hierarchische Struktur auf. Schlüsselakteure im Zusammenhang mit der Gesundheit von Studierenden an der Universität wurden ermittelt. Die Wahrscheinlichkeit der Zusammenarbeit zwischen den Netzwerkakteuren wird durch strukturelle und attributive Faktoren bestimmt.

Schlussfolgerung: Die vorliegende Arbeit erweitert das Wissen über organisationale Strukturen und Prozesse, die sich in der interdisziplinären Zusammenarbeit von Akteuren gesundheitsfördernder Hochschulen entfalten. Die Ergebnisse dieser Studie können für die Weiterentwicklung des bestehenden Netzwerks genutzt werden und bieten auch Ansatzpunkte für die Netzwerkarbeit an anderen Hochschulen.

Schlüsselwörter: Netzwerkanalyse, Kooperation, Gesundheitsförderung

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1 General Introduction

Health promotion for tertiary students is of particular importance from a public health perspective (Stewart-Brown et al., 2000; Sweeting et al., 2021). First, they represent a significant proportion of the population in need of health promotion[1]. According to preliminary results from the German Federal Statistical Office (Destatis, 2022b, 2022c), a total of 2,947,500 students were enrolled at the 423 higher education institutions[2] in Germany in the winter semester of 2021/2022. Students make up the largest group out of the members of the universities accounting for an average of 80% (Hartmann, 2021). The number of university students has risen consistently for 14 years and reached a plateau in 2021 for the first time since 2007 (number of students: 1,941,763). The average age of students in Germany is 23.4 years (Destatis, 2022a), but despite their young age, different health problems like stress (Ribeiro et al., 2018), burnout (Kaggwa et al., 2021), depression (Ibrahim et al., 2013), overweight and obesity (Peltzer et al., 2014), sleep disorders (Jiang et al., 2015), and migraine (Wang et al., 2016) are common among university students as several systematic reviews point out. These international findings have been replicated in a large-scale study with 6,198 university students in Germany (Grützmacher et al., 2018). The results also show that university students describe themselves as less healthy than the age-appropriate proportion of the non-student population.

Second, the shift from secondary to tertiary education is a critical moment during the transition from adolescence to adulthood causing substantial life changes (e.g., leaving the parental home and organizing the daily routine autonomously; Aceijas et al., 2017; Ackermann & Schumann, 2010) and entailing various stressors including general academics stressors and exams, lack of time, financial worries, the uncertainty of plans after graduation, expectations both from self and others, and loneliness (Hurst et al., 2013; Wörfel et al., 2016). Since the

[1] Health promotion is understood as the process of enabling people to increase control over their health and its determinants, and thereby improve their health (World Health Organization, 2006).
[2] There are six different types of higher education institutions in Germany (Destatis, 2022b): 108 universities, 211 universities of applied science, 52 colleges of art and music, 30 colleges of public administration, 16 theological colleges and 6 pedagocial colleges. For the sake of readability, all types of higher education institutions will be referred to as universities in the following (World Health Organization, 1998).

implementation of the bachelor's/master's program in German universities via the Bologna reform study-related burdens on university students have further increased (Gusy et al., 2010; Thees et al., 2012).

Third, according to numerous systematic reviews, university students are vulnerable to engaging in risky coping and health behaviors like alcohol consumption (Davoren et al., 2016; Karam et al., 2007; Wicki et al., 2010), unhealthy eating behavior (Bernardo et al., 2017), physical inactivity (Irwin, 2004; Pengpid et al., 2015), sedentariness (Castro et al., 2020), smoking (Guerra et al., 2017; Patterson et al., 2004), use of other substances (Papazisis et al., 2018; Skidmore et al., 2016), internet addiction (Shao et al., 2018), suicidal thoughts and behaviors (Mortier et al., 2018), and the inability to appropriately find, understand, evaluate, and apply health information to make health-related decisions (Kühn et al., 2022). This is of great importance because the behavioral habits in the years to come are formed during the period of early adulthood (Aceijas et al., 2017; Haas et al., 2018) and the health-related lifestyle during the study period can have a lasting impact on health in later adulthood (Lawrence et al., 2017). COVID-19 may have exacerbated the impact of stressors and existing health issues evident before the outbreak (Vindegaard & Benros, 2020).

In addition, it should be mentioned that students hold a potential health-promoting multiplier role as future leaders, decision makers, as well as parents and might therefore have a decisive influence on the health of others (Dooris & Doherty, 2010a). Moreover, there is evidence of a positive association between health as well as health behaviors and academic achievement of university students (Stock, 2017). Since university dropouts cause high economic costs (Berthold et al., 2015; Neugebauer et al., 2021), promoting health-related competencies of university students and improving study and campus-based living conditions can make an important financial contribution to society (Blüthmann, 2014).

However, not only because of the size of the status group, the young age average, the special stress situation in a vulnerable phase of life, but also because of the short time spent at the university, special requirements must be placed on health promotion for university students (Dietz et al., 2020). For Germany, the

mean total duration of study for a bachelor's degrees is 7.5 semesters, and the mean total duration of study for a master's degrees is 11.7 semesters (Destatis, 2018). With the *Prevention Act of 2015*, legislators have strengthened health promotion, particularly for students, at universities at the federal level in Germany (Hartmann et al., 2016). Under the German Framework Law on Higher Education, universities were until then only required to participate in the social support of enrolled students (Hartmann, 2021). Previously, only the student support services as legally independent institutions, autonomous from the German universities, were responsible for health promotion initiatives for university students (Hartmann, 2021).

Referring to a current umbrella-review (Dietz et al., 2020), there is a wide range of approaches promoting modifiable health influencing factors of university students. Overall, interventions aiming at the individual level, as opposed to environmental-level interventions, are overrepresented (Dietz et al., 2020), likely because implementation and evaluation of environmental-level interventions are more complicated (Fernandez et al., 2016). However, environmental-level health interventions have greater reach and potential impact than individual-level interventions (Capewell & Capewell, 2018; Frieden, 2010), because they use micro (e.g., social support), meso (e.g., culture), and macro-level mechanisms (e.g., intersection of different settings), all of which can initiate and sustain health changes beyond individual-level mechanisms (e.g., affect or cognition; Lewis et al., 2017). These considerations are anchored theoretically in state-of-the-art ecological models for the explanation of health (and health behavior) recognizing that health (and health behavior) go beyond the individual level and are affected by environmental characteristics (e.g., economic, social, organizational, and cultural conditions; Barton & Grant, 2006; Burke et al., 2009; Fisher, 2008; Glanz et al., 2008; Stokols et al., 2003). Place and context are therefore themselves important and modifiable determinants of health and health behavior, and health promotion should thusly focus on creating supportive environments at the location where people spend their lives (Green et al., 2000; Stokols, 1996).

Although no models are available to specifically describe the influence of the university environment on student health, established general models of ecological

health have been applied previously (see Fig. 1; Mark Dooris, 2013). The applicability of models from other settings (e.g., healthy cities) is supported by the similarity in terms of the mechanisms at action (Barton & Grant, 2006; Stokols, 1996). For example, Dooris adopted a holistic ecological framework (Stokols, 1996), recognizing that students' health is a multi-layered and multi-component concept and that it is determined by a complex interaction of factors operating at personal, organizational, and environmental (physical, political, economic, cultural, social, and cultural) levels. In the two well-regarded publications *Theorizing healthy settings: a critical discussion with reference to Healthy Universities* and *Conceptualizing the 'whole university' approach*, Dooris and colleagues (2014; 2020) set out in detail, that the health and (health-related) behavior of students is not only a consequence of making free choices but first of all an outcome of the university setting around them.

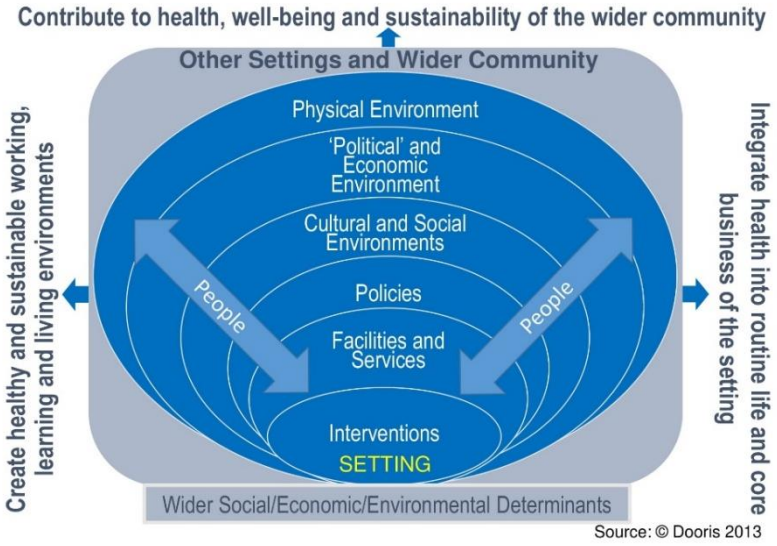

Figure 1: An Ecological Model of Health for the University Setting (Dooris, 2013).

The aforementioned findings call for action on innovative setting-based strategies to promote the health of university students (Dooris, 2006). In doing so, they confirm numerous voices in the field of health-promoting universities that emphasize the need for a whole-university approach that considers the complex interactions and interconnections among environmental characteristics (Dooris et al., 2014; Dooris & Doherty, 2010b; Newton et al., 2016; Pathare, 2021). Thus, the view that health promotion should be about persuading people to adopt certain healthy

behaviors has been shifted to building the foundation of a supportive environment (Dooris et al., 2014; Dooris, 2001). Organizational conditions play a special role in this context (Darker et al., 2021; Dooris et al., 2020; Hartman et al., 2018; Sarmiento, 2017). The importance of incorporating and leveraging multiple components of the university system by integrating health into policies and areas such as environment and facilities, support services, curriculum, and research is emphasized time and again (Dooris et al., 2020; Newton et al., 2016; Pathare, 2021). Here, the value of proactively coordinating action through a multi-stakeholder oversight group (e.g., a steering group) or other mechanism is underlined.

Multidisciplinary cooperation among actors and the resulting intersectoral synergies are considered cornerstones in the process of incorporating health promotion practices into everyday university life to break down barriers and provide greater access to health promotion services (Dooris, 2001; Dooris, 2006; Dooris et al., 2014; Dooris & Doherty, 2010a; Ewing et al., 2007; Sarmiento, 2017). Collective action by a wide range of stakeholders is essential for effective health promotion since a single stakeholder can hardly be in control over the complex interplay of multifaceted determinants of health in a target population (Batras et al., 2014; Poland et al., 2009; Woulfe et al., 2010). This is especially true for health-promoting universities in which many actors from different professions and hierarchical levels must be involved (Hartman et al., 2018; Hartmann, 2021).

The *Okanagan Charter: An International Charter for Health Promoting Universities and Colleges* (2015), developed as a guide for health promotion in universities, recommends working according to the so-called *setting approach*[3], which has been considered a core strategy of health promotion since the Ottawa Charter of the World Health Organization in 1986 and whose importance was once again underlined in the course of the Jakarta Declaration of the World Health Organization in 1997. Specifically, this means that relevant actors from various disciplines and sectors within the campus community should be cooperatively involved in the process of embedding health into all aspects of campus culture

[3] A setting is a social context, for example an organization, in which people spend time in their daily lives and which influences their health as well as in which many people are accessible for health promotion (Dadaczynski et al., 2016; Hartung & Rosenbrock, 2015).

(e.g., curricula, teaching, research) and providing health-promoting activities for university students based on a systemic organizational development regarding the structures and processes in the setting. This should include actors and organizations that are only indirectly involved in university students' health (Dooris et al., 2020). The German Network for Health Promoting Universities also regards the setting approach to be a crucial strategy of action in the context of health promotion at universities (German Network for Health Promoting Universities, 2020) and has defined it as a quality criterion for the promotion of university students' health. Hungerland et al. (2021) show in their article that actors of different levels (e.g., executives, members, representatives, professionals, committees) can basically play a role in health-promoting universities.

Partnerships offer multiple benefits, including the exchange of information, knowledge gain, building trust and increasing reach with the target population, access to and provision of additional resources, avoidance of duplicate structures, boost to innovation, the possibility of achieving higher goals, the opportunity for task sharing, and pursuit of a holistic approach (Batras et al., 2014; Varda et al., 2008). Partnership refers to the joint cooperation of different individuals, groups, or organizations that pursue a goal and have similar visions regarding the subject of the cooperation (Hartmann & Sonntag, 2015). They are established to achieve better goals and are essential throughout the entire process, from ideation to execution (Hartman et al., 2018). Gulati et al. (2012) define cooperation as the joint pursuit of agreed-on goals in a manner corresponding to a shared understanding about contributions and payoffs. Cooperation is often used interchangeably with collaboration or coordination, although the terms certainly have different meanings on closer examination. Starting from the Latin etymology, cooperation (*cum opera*) means operating together with others (in general regarding a singular goal). Collaboration comes from *cum laborare*, which means working together with others (in general regarding a shared goal). Rosenkopf and Padula (2008) highlight the necessity of socioeconomic investments like sharing resources, costs, and risks, in their description of cooperation in contrast to collaboration. Coordination in turn stands for *cum ordinare*, which can be translated as organizing together with others. However, in detail the distinction between

cooperation, collaboration, and coordination remains somewhat unclear (Castañer & Oliveira, 2020).

Since universities are complex organizations with several subdivisions with distinct individuality such as faculties, departments, institutes, or chairs as well as numerous central service units (Hartmann, 2021; Newton et al., 2016), systematically navigating health promotion in terms of partnership and intersectoral action is necessary for it to be effective and efficient (Dooris et al., 2021). Actors also may not have a history of working together or even view themselves as having related goals, making setting-based health promotion a difficult undertaking (Farrugia & Lane, 2012; Poghosyan et al., 2016). Institutions are most likely to choose health-promoting setting-based actions that are closest to their mission (e.g., health education; support for health promotion research; changes to teaching/assessment; Fernandez et al., 2016; Suárez-Reyes & van den Broucke, 2016; Sweeting et al., 2021). Health promotion efforts that link health promotion objectives with the original objectives of the respective institution (*health co-benefits*) have proven to be particularly successful (Pelikan & Dietscher, 2015).

In contrast to traditional social science methods, social network analysis is uniquely suited to explore the cooperation between actors by visualizing and describing relationships between actors as well as the overall network structure (Poghosyan et al., 2016; Wasserman & Faust, 2012). The fundamental principle of network perspective is to view actors (*nodes*) as part of a system with dependencies on other actors (Borgatti & Foster, 2003). While traditional approaches in the social sciences focus on attributes, the network approach focuses on relationships (*ties*). In the past, various intra- and interorganizational public health networks were examined using social network analysis to visualize and examine structural characteristics and cooperation processes: active living (An et al., 2017; Buchthal et al., 2013), cancer support (McKinney et al., 1993; Ramanadhan et al., 2012), children's health initiatives (Mulroy, 1997; Valente et al., 2008), community care (Franco et al., 2015; Valente et al., 2010; Weiner & Alexander, 1998), elderly care (Bolland & Wilson, 1994; Kaluzny et al., 1998; Lang et al., 2005), HIV/AIDS service (Kwait et al., 2001), injury prevention and control (Harris et al., 2017), mental health services (Becker et al., 1998; Nakao et al., 1986; Provan &

Milward, 1995; Tausig, 1987), physical activity promotion (Timm et al., 2021), prevention of diabetes (Provan et al., 2005), tobacco control (Fujimoto et al., 2009; Harris et al., 2008; Luke et al., 2010; Mueller et al., 2004), and women's health (Eisenberg & Swanson, 1996; Phillips, 1991).

A multi-methodical, but not network analytical, approach to mapping out and characterizing health-promoting structures of a university was used by Sarmiento (2017). Information on localization, resources, and partnerships of health promotion initiatives was collected via semi-structured interviews with stakeholders in health-related roles. Examination of partnerships, however, was limited, as is commonly the case in literature on health-promoting universities, to the naming of allied university actors (Darker et al., 2021; Ferreira et al., 2018; Suárez-Reyes & van den Broucke, 2016). In their study on Constraints and Facilitators to Developing Collaborative Campus Wellness Partnerships (Hartman et al., 2018) qualitative data were collected from 127 campus recreation professionals. Of the participants, 81.5% indicated that they were engaged in at least one wellness partnership. The vast majority of these partnerships were informal, meaning that respondents indicated that they did not have a memorandum of understanding or written agreement about the roles and responsibilities of partners. The most frequently mentioned partners in this study were Student/Campus Health Services (including Counseling Services), Student Housing, Student Life/Student Affairs, Academic Departments, and Dining Services. Despite this evidence, there is a research gap on health-promoting universities, since no corresponding network has been examined regarding in-depth information about structural characteristics and their conditions using social network analysis. To be able to carry out systemic, sustainable, and successful health promotion in the microcosm of the university, it is essential to understand, describe, analyze, and explain the setting and its influencing factors sufficiently in advance (Sweeting et al., 2021). The present work contributes a part to overcome the indicated research deficit by increasing the knowledge of structures and processes unfolding in relations among actors in health promotion at university. Specifically, this thesis explores the following questions:

- Which cooperation structures are present at the health-promoting university at hand?
- What mechanisms underlie cooperation at the present health-promoting university?
- What can a cooperative process for the promotion of students' health at university look like?

By answering these questions, universities can contribute to student health promotion by creating a healthy university environment and in this way contribute to successful studying overall (Kellner et al., 2021).

Paper I: Bachert, P., Wäsche, H., Albrecht, F., Hildebrand, C., Kunz, A. M., & Woll, A. (2021). Promoting Students' Health at University: Key Stakeholders, Cooperation, and Network Development. *Frontiers in Public Health, 9*, 680714. https://doi.org/10.3389/fpubh.2021.680714

Research Question: Which cooperation structures are present at the health-promoting university at hand?

The aims of this study (Bachert et al., 2021a) were to visualize and describe the positions and characteristics of the network actors to identify key stakeholders and examine organizational relationships to determine the characteristics of the complete network of (potential) health-promoting actors at university. The question of the relevance of the actors to be involved in the health promotion process at the university is of great importance (Dooris et al., 2020; Hartman et al., 2018; Sarmiento, 2017). Therefore, using social network analysis, 33 university actors were asked about their cooperation behavior and the relevance of the other actors in the network. The network shows a flat, non-hierarchical structure. According to the respondents, the University Sports Center is considered the most important actor in the context of student health. Presidium and a health-related institute play an integral role in terms of network functionality. In the health-promoting network, numerous opportunities for further integration and interaction of actors exist. The interconnectedness of the student groups in the network indicates a homophily effect, which is known from network analyses in other settings

(Brownson et al., 2010). This knowledge about the cooperation structures provides several starting points for network development and for optimizing the processes (Bachert et al., 2021a). However, exploratory investigation of the patterns of cooperative structures within the network does not allow explanatory conclusions to be drawn about the mechanisms underlying cooperation.

Paper II: Bachert, P., Wolbring, L., Hildebrand, H., Woll, A. & Wäsche, H. (under review). Analyzing Mechanisms of Interdisciplinary Cooperation in Promoting Students' Health at University. *BMC Public Health*

Research Question: What mechanisms underlie cooperation at the present health-promoting university?

The purpose of this study (Bachert et al., under review) was to obtain insight into the underlying mechanisms of cooperation between university actors in a health-promoting network and to identify the structural and attributive factors associated with establishing cooperation between actors in the observed network. Derived from this, several hypotheses regarding attributive and structural effects were tested. Information regarding the underlying processes of tie formation and network emergence is essential in the process of setting-based health promotion (Batras et al., 2014; Dooris et al., 2021). Sweeting et al. (2021) highlight the requirement for increased understanding of the efficacy and mechanisms of whole/healthy approaches within tertiary education settings. Exponential random graph models were estimated to test corresponding hypotheses based on a social network analysis consisting of 33 university actors. Results show that attributed competence predicts cooperation. Several structural predictors are essential in determining the likelihood of cooperation between actors involved in the network. Subsequently, a better understanding of how to build and develop partnerships among actors of health-promoting universities in the future is obtained (Bachert et al., under review). Partnerships can especially be considered successful if they lead to interventions that actually promote health of the target group.

Paper III: Bachert, P., Hildebrand, C., Erley, N., Jekauc, D., Wäsche, H., Kunkel, J. & Woll, A. (2021): Students on stairs: a participatory approach using decisional cues in the form of motivational signs to promote stair use. *Journal of American college health*. https://doi.org/10.1080/07448481.2020.1845704.

Research Question: What can a cooperative process for the promotion of students' health at university look like?

The goal of this study (Bachert et al., 2021b) was to assess whether an environmental-level health intervention designed in a participatory manner could have an impact on health indicators of university students. Various student groups (expert group of students of a health-related course of studies, focus group with students from various study programs, and students with special needs) as well as university units (facility management, safety department, office of construction, and building administrators of different departments) were cooperatively involved in the implementation of changes to the infrastructure (point-of-decision prompts for physical activity in several university buildings) at university, which was examined with direct observations. Intersectoral synergy as a result of cooperation is considered a pivotal factor in setting-based health promotion (Dooris et al., 2014; Sarmiento, 2017). Our results indicated that stair usage of university students could be sustainably promoted via the adaptation of the campus environment. Based on a cooperative effort by a wide range of university actors effective setting-based health-promoting practices can be integrated relatively simply into everyday university life.

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2 Paper I: Key Stakeholders, Cooperation and Network Development

Slightly modified version of the published paper

Bachert, P., Wäsche, H., Albrecht, F., Hildebrand, C., Kunz, A. M. & Woll, A. (2021). Promoting Students' Health at University: Key Stakeholders, Cooperation, and Network Development. *Frontiers in Public Health, 9*, Art. Nr.: 680714. https://doi.org/10.3389/fpubh.2021.680714

2.1 Abstract

Background: Cooperation among university units is considered a cornerstone for the promotion of students' health. The organizational structures of health-promoting networks at universities have rarely been examined so far. Shedding light on partnerships is generally limited to the naming of allied actors in a network. *Objectives and methods*: In this study, we used network analysis intending to visualize and describe the positions and characteristics of the network actors, and examine organizational relationships to determine the characteristics of the complete network. *Results*: The network analysis at hand provides in-depth insights into university structures promoting students' health comprising 33 organizational units and hundreds of ties. Both cooperation and communication network show a flat, non-hierarchical structure, which is reflected by its low centralization indices (39-43%) and short average distances (1.43-1.47) with low standard deviations (0.499-0.507), small diameter (3), and the non-existence of subgroups. Density lies between 0.53-0.57. According to the respondents, the University Sports Center is considered the most important actor in the context of students' health. Presidium and Institute of Sport and Sports Science play an integral role in terms of network functionality. *Conclusion*: In the health-promoting network, numerous opportunities for further integration and interaction of actors exist. Indications for transferring results to other universities are discussed. Network analysis enables universities to profoundly analyze their health-promoting structures, which is the basis for sustained network governance and development.

2.2 Introduction

Problem statement and relevance

Despite their young age, university students are a vulnerable group from a health perspective (Hurst et al., 2013; Ribeiro et al., 2018; Stewart-Brown et al., 2000). Because of the potential multiplier role of university students as future leaders and decision makers, health promotion in higher education institutions is of special importance (Dooris & Doherty, 2010a). Because universities are complex organizations, systematically navigating health promotion is necessary for it to be effective and efficient (Dooris et al., 2021).

Therefore, health-promoting universities are being called upon to work according to the *setting approach*, which means that relevant stakeholders from different disciplines and sectors within the campus community should be cooperatively involved in the process of embedding health into all aspects of campus culture and of providing health-promoting activities for students (Okanagan Charter: An International Charter for Health Promoting Universities and Colleges, 2015; Tsouros et al., 1998). Collective action by a wide range of stakeholders is been seen as a key for effective intervention delivery in health promotion since a single stakeholder can hardly be in control over the complex interplay of determinants of a targeted population's health (Batras et al., 2014; Poland et al., 2009; Woulfe et al., 2010).

By cooperating, stakeholders can attain and provide additional resources, share information and knowledge, minimize the duplication of effort, reach additional members of the target audience, earn greater credibility and tackle the determinants of health in a holistic approach through the provision of integrated services (Batras et al., 2014; Gregson et al., 2011, S68; Krauss et al., 2004; Provan, Veazie et al., 2005; Varda et al., 2012). However, stakeholders from various disciplines with unique expertise, interests, values, and expectations may not have a history of working together or even view themselves as having related goals, making setting-based health promotion a difficult undertaking (Buchthal et al., 2013; Farrugia & Lane, 2012; Poghosyan et al., 2016).

State of research and research gap

Cooperation processes and structural characteristics of various public health networks have been studied in the past, including active living networks (An et al., 2017), health care and patient safety networks (Bae et al., 2015), community academic partnerships for health (Franco et al., 2015), community care networks (Valente et al., 2010; Weiner & Alexander, 1998), substance abuse prevention networks (Fujimoto et al., 2009; Krauss et al., 2004), children's health initiative coalitions (Valente et al., 2008), elderly care networks (The Healthy Aging Research Network Writing Group for CDC, 2006), HIV/AIDS service organizations (Kwait et al., 2001), mental health services (Johnston, 2001; Provan & Wilward, 1995), woman organizations (Eisenberg & Swanson, 1996; Phillips, 1991), and cancer support networks (McKinney et al., 1993).

The number of colleges and universities promoting health for students is rapidly increasing (Newton et al., 2016). The organizational structures of health-promoting networks at universities, however, have rarely been examined so far, and that although multiservice cooperation among the university community is considered a cornerstone for the promotion of health in the university setting (Dooris & Doherty, 2010a, 2010b). In their study on implementation status quo of the health-promoting university concept, Suárez-Reyes et al. (2019) have pointed out that "the key principles of health-promoting universities and the framework for action, along with the key components for their implementation, are clearly described, but information on how universities make use of these guidelines to operate in a real context is scarce". Newton et al. (2016) stated in their study on the operationalization of the concept of healthy universities, that there is a need for a whole-university approach that pays attention to the complex interactions and interconnections between component parts and highlights how the organisation can function effectively as a social system. Reviews have indicated that cooperative practice among units of the university does seem to take place in the context of student health (Ferreira et al., 2018; Suárez-Reyes & van den Broucke, 2016), but evidence about communication and cooperation among units promoting health, especially for university students, is almost non-existent, while other aspects of promoting students' health at university are relatively well studied (Dietz et al.,

2020; Maselli et al., 2018; Wunsch et al., 2021). A multi-methodical but not network analytic approach to map out and characterize health-promoting structures was used at the Florida International University (USA; Sarmiento, 2017). Here, information on localization, resources, and partnerships of health promotion initiatives was collected via semi-structured interviews with stakeholders in health-related roles among other things. Shedding light on partnerships, however, is then limited again, as is commonly the case (Ferreira et al., 2018; Suárez-Reyes & van den Broucke, 2016), to the naming of allied actors, and does not provide in-depth information about structural characteristics of networks promoting health at university.

Theoretical background

The present network analysis falls into the research branch of *organizational network analysis* (Luke & Harris, 2007). An organization can be conceptualized as a network in which organizational members or units (consisting of the major representatives of those organizations for example) are nodes interacting with each other, establishing relationships (Brass et al., 2004). These networks between organizational units are referred to as *intraorganizational networks*, as opposed to *interorganizational networks*, where the focus is on networks between different organizations (Baum, 2017; Wäsche et al., 2017). Within the research branch of *organizational network analysis*, the present network analysis belongs to the category of *network development research*. Here, so-called *network structure constructs* at all three levels (node, dyadic & network) are utilized to capture detailed structural features of networks (Carpenter et al., 2012). By capturing the structural features of a network, network structure constructs can help to understand the positions and roles of actors and indicate the available opportunities for progress in the network (Gulati & Gargiulo, 1999).

Purpose

In this study, we used network analysis with the aim to

- visualize and describe the positions and characteristics of the network actors to identify key-stakeholders

- examine organizational relationships to determine the characteristics of the complete network
- explore the network structures to designate starting points for network development.

The research questions are as follows

- Which actors are relevant concerning student health?
- How is communication and cooperation between actors structured in the network?
- Which network-related optimization potentials can be identified?

2.3 Methods

Setting

To address student health issues at the German university at hand the Institute of Sports and Sports Science and the Central Scientific Institution for Key Competencies launched a participatory health promotion project focused on identifying barriers and opportunities related to integrating evidence-based health promotion programs offered on the university campus in partnership with the Presidium, the Techniker Krankenkasse (German health insurance), Student Support Service, University Sports Center, and student representatives. The university has a long history of health promotion regarding staff members (corporate health management) and partially regarding university students (e.g., health-related courses at the University Sports Center or key qualifications for coping with academic stress). However, a holistic management approach for the promotion of students' health was undertaken at the beginning of this project in 2017. Stakeholders of the project agreed on developing a community-based participatory research approach (Wallerstein et al., 2018). Through cooperation with the different stakeholders at the university, it was expected that structural change could be implemented more efficiently. Some of these actors provide health promotion or education activities, others were not traditionally associated with health and academic stress themes. This paper reports the findings from a network analysis

among actors of the university, which was conducted after the project had been in operation for about two and a half years. The network analysis primarily provides data on the extent to which actors interacted with one another in the network.

Sampling

To identify all actors that address student health at university, a multifaceted snowball sampling process was initiated (Brownson et al., 2010; Buchthal et al., 2013; Guldbrandsson et al., 2012). First, a pre-defined list was created by the researchers based on the research of project proposals and documents and a screening of the literature. Then the head managers from the participatory health promotion project for students from the Institute of Sports and Sports Science and the Central Scientific Institution for Key Competencies were asked as key informants to identify the actors with a unique role and others they deemed relevant in the area of health promotion at the university. This resulted in a final sample of 33 actors, who focus on understanding or promoting the health of students at university or who are potentially able to influence student health. The actors were quite diverse. Some of them were actual health providers, others provided health-related information and education, and still others had only indirect involvement with students' health. 14 of these organizations were engaged in the project at the time (via membership of the steering committee or through engagement in the working group), and the rest was identified as potentially relevant.

Questionnaire

The questionnaire developed was based on previous work on health- and physical activity-related networks done (Bös, K. & Ertmann, D., 2004; Brownson et al., 2010; Buchthal et al., 2013; Slonim et al., 2007; Wäsche, 2015). It requested basic information on the estimation of health topics and potency of actors but focused primarily on obtaining information on relationships regarding communication and cooperation among the actors. The questionnaire comprised 18 questions. The quantitative relational constructs measured among the university units were communication and cooperation, operationalized as the frequency of contact and type of cooperation. For each question, a list of the 33 actors was

provided. Regarding communication, respondents were asked to indicate, how often they are in contact with all of the 33 actors. Communication frequency response options ranged from “never” (0), “less than annually” (1), “annually” (2), “half-yearly” (3), “monthly” (4), „weekly“ (5) to „daily“ (6). In matters of cooperation, respondents were asked, how they would describe their relationship with each of the 33 actors. The cooperation response scale ranged from no cooperation (0); information sharing only (1); informal cooperation (loose cooperation to reach common objectives) (2); formal cooperation (close cooperation in a team to reach common objectives) (3); partnership (close cooperation for longer time period, e.g., in several projects) (4). In order to identify further starting points for network governance and development, respondents were additionally asked about their points of contact regarding their area of work with several health-related topics, perceived importance of these health topics for student health (on a five-point Likert scale from 1=unimportant to 5=very important), the relevance of the other actors regarding health topics, and the importance of the other actors regarding student health per se (on a five-point Likert scale from 1=unimportant to 5=very important). Health-related topics were identified by scanning the research field of health-promoting universities with a focus on students. Apart from that, questions were asked about service duties (e.g., freedom of choice), staffing level, and the employment relationship (*Note: The analysis of these questions is not part of this publication*). The respondents were also given the opportunity to list further relevant actors and health topics, which were not included in the list and which they thought were relevant to students’ health. Most questions and answers were administered with accompanying definitions and examples. The questionnaire was prefaced with instructions and data protection information and was piloted with the head of the Corporate Health Management and the deputy managing director of the Central Scientific Institution for Key Competencies.

Data collection

Quantitative and qualitative organizational network data were collected during winter semester 2019/2020 by highly-structured face-to-face-interviews from trained research assistants using an interview guide in an interactive format with actor and health topic lists and response scale cards. The main representative of

each of the 33 units (in generally the executive director or in some cases: a staff member who was more knowledgeable about the issue) received a personalized interview request for this purpose, including a cover letter explaining the research study and a privacy statement. Individuals were known from most units, otherwise, contact persons were researched at the homepages of the units. Informed written consent was obtained from all respondents before the start of the interview. The average interview lasted about 60 minutes. All in all, data collection took 6 months. Approval for this study was granted by the staff council and the data protection office of the university as well as the staff council of the Student Support Service. In the end, 28 out of 33 units completed the survey providing an 85% response rate. Three of the 33 units (Student Groups, Deaneries, and Institutes) represented a collective of various actors and were therefore not interviewed. The General Student Committee and the Student Working Group for Culture and Communication were not available for an interview. In total, 35 persons were interviewed, since the Institute of Sports and Sports Science (3 respondents), the Central Scientific Institution for Key Competencies (5 respondents), and the Student Support Service (2 respondents) in their roles as central stakeholders in the context of student health had more than one respondent.

Data analysis

Survey data gathered through the questionnaire were entered to SPSS 25 Statistical Package by study ID for cleaning and initial data exploration on basis of a codebook. 10% of data were randomly double-checked for accuracy – the agreement was 100%, why a higher double-check was refrained from. Data from the two network questions was then exported into Microsoft Excel for the creation of adjacency matrices, indicating which actors reported links of cooperation and communication to other actors. To reconcile divergent response pairs two techniques were used: reconstruction (when only one actor in the dyad provided a valid response to a question, response given by the other actor in the pair was used) and symmetrizing (minimization was used to resolve rating discordances between two actors in a dyad). When both actors in the dyad did not give a valid response to a question, it was treated as a missing value, which was the case for 20 (5 non-interviewed actors x 4) out of 1056 ties for both networks,

corresponding to a missing rate of less than two percent. If multiple respondents were interviewed from one unit, we used the responses given by the person highest in the hierarchy (Krauss et al., 2004). Data were then managed and analyzed using UCINET 6. For data analysis, various descriptive and statistical procedures were applied. To identify actors' positions and key stakeholders, various centrality parameters (degree, betweenness, closeness, eigenvector) at the node level of analysis were calculated and assessed for all actors. For an analysis of structural cohesion at the network level, various measures of network cohesion were calculated (Hanneman & Riddle, 2005; Luke & Harris, 2007; Poghosyan et al., 2016): average degree (average number of edges per node in the graph), centralization (extent to which the graph shows a centralized structure), density (number of existing ties divided by the number of possible ties), fragmentation (extent to which the network is broken into fragments of unconnected nodes, dyads, and cliques), average distance (average number of steps along the shortest paths (geodesics) for all possible pairs of network nodes), diameter (largest geodesic distance in the network). To analyze the association between the network of communication and the network of cooperation, inter-network correlations were calculated using the quadratic assignment procedure (QAP; Wäsche, 2020). Network maps representing cooperation and communication between actors were visualized using GEPHI 0.9.2.

2.4 Results

Respondents (N=35) were asked to select from 13 different topics related to students' health, that play a role in the course of their everyday professional lives. On average, each respondent selected six topics. Stress management (71% of all respondents), workplace design (63%), and key qualification and further education (63%) were mentioned most frequently, followed by sports and relaxation (60%), study organization (54%), social counseling (51%), study counseling (51%), curriculum (49%), campus design (46%), campus safety (40%), nutrition (29%), addiction counseling (17%), and health diagnostics (14%).

The network actors interpreted the question openly, which means that they assumed to have points of contact with the topics, even if they could not present

any concrete offers themselves, but only referred students to offers of other actors. The respondents also found the response to the topics suitable if they were only relevant for a certain small part of the student body with whom they were in contact. Health-related topics mentioned additionally, once each, were health assessment, student representation possibility, sustainability, sleep and peer-to-peer counseling. When asked to choose the topic, which plays the most important role in the everyday professional lives of the actors, respondents mentioned study organization (n=4), sports and relaxation (n=4), key qualification and further education (n=3), workplace design (n=3), study counseling (n=3), and named once in each case: campus design, nutrition, health diagnostics, social counseling, campus safety and sustainability. 11 respondents did not make a statement in this regard, because they could not decide on one of the 11 topics.

When asked for the importance of the topics concerning students' health, respondents regarded stress management (M=4.46, SD=0.7), social counseling (M=4.34, SD=0.8), and sports and relaxation (4.23, SD=0.9) as the most important topics, followed by workplace design (M=4.11, SD=0.9), study counseling (M=4.00, SD=1.1), study organization (M=3.80, SD=1.3), nutrition (M=3.77, SD=1.0), curriculum (M=3.71, SD=1.2), key qualification and further education (M=3.69, SD=1.1), addiction counseling (M=3.57, SD=1.0), campus design (M=3.40, SD=1.1), campus safety (M=3.34, SD=1.0), and health diagnostics (M=3.20, SD=1.0).

To assess how respondents view other actors in the network concerning students' health, respondents were asked to rate the importance of each actor. Respondents regarded the University Sports Center (M=4.66, SD=.0.5), the Representative for Students with Special Needs (M=4.51, SD=0.6), and the Student Support Service (M=4.46, SD=0.9) as the most important actors (see Tab. 1). The mean ratings ranged between 2.24 and 4.66. Interestingly, some of the actors (e.g., Representative for Students with Special Needs, Study Center for Visually Impaired Students and Medical Services) deemed important here play a minor role in previous efforts to promote student health within the participatory health promotion project. This result corresponds to the network maps and structure constructs presented later.

Table 1: Importance of the units

Units	Mean (SD)	N
University Sports Center	4.66 (0.5)	35
Representative for Students with Special Needs	4.51 (0.6)	35
Student Support Service	4.46 (0.9)	35
Corporate Health Management	4.35 (0.9)	34
Institute for Sports and Sports Science	4.29 (0.8)	35
Study Center for Visually Impaired Students	4.09 (0.9)	35
Presidium	4.03 (1.1)	35
Central Scientific Institution for Key Competencies	4.00 (0.7)	35
Sports Club	3.94 (0.9)	34
Medical Services	3.91 (1.1)	35
Student Group: Nightline	3.89 (1.1)	35
General Student Committee	3.66 (0.9)	35
Library and Learning Space Development	3.60 (1.2)	35
Equal Opportunities	3.59 (1.0)	34
Institutes	3.57 (1.0)	35
Service Unit for Higher Education and Student Affairs	3.52 (1.2)	33
Safety and Environment	3.52 (1.1)	33
Specialists for Occupational Safety	3.51 (1.1)	35
Student Groups	3.50 (1.0)	32
Center for Information and Counseling	3.44 (1.1)	34
Student Services	3.43 (1.1)	35
Student Parliament	3.37 (1.2)	35
Diversity Management	3.35 (1.1)	34
Campus Development	3.33 (1.1)	33
Student Working Group Culture and Communication	3.26 (1.1)	35
Deans' Offices	3.26 (1.2)	35
International Students Office	3.24 (1.2)	34
Student Council Conference	3.06 (1.2)	35
Center for Applied Cultural Studies	2.91 (1.0)	35
Green-Alternative Student Group	2.86 (1.0)	35
Center for Teacher Education	2.79 (1.1)	33
Human Resources Development and Vocational Training	2.77 (1.2)	35
Innovation and Relations Management	2.24 (1.1)	33

Respondents were also asked to indicate the most important actor regarding the 11 health-related topics. The mentioned actors with the respective percentage number can be seen in Table 2 for every single topic. It can be seen that the perceived competence in terms of professional suitability and responsibility for a topic is distributed among different actors for each topic.

Table 2: Most competent units regarding the health-related topics

Topics	Most competent units	N
Campus design	Campus Development (26%), Safety and Environment (20%), Facility Management (9%)	35
Curriculum	Institutes (38%), Deans' Office (24%), Service Unit for Higher Education and Student Affairs (18%)	34
Nutrition	Student Support Service (39%), Institute for Sports and Sports Science (27%), Corporate Health Management (15%)	33
Workplace design	Specialists for Occupational Safety (27%), Library and Learning Space Development (21%), Facility Management (12%)	34
Health diagnostics	Institute for Sports and Sports Science (88%), University Sports Center (6%)	33
Key qualification and further education	Central Scientific Institution for Key Competencies (65%), Human Resources Development and Vocational Training (12%)	34
Social counseling	Student Support Service (43%), General Student Committee (17%), Study Center for Visually Impaired Students (9%)	35
Sports and relaxation	University Sports Center (54%), Institute for Sports and Sports Science (37%)	35
Stress management	Student Support Service (25%), Central Scientific Institution for Key Competencies (25%), Institute for Sports and Sports Science (16%), Corporate Health Management (16%)	32
Study Counseling	Center for Information and Counseling (65%), Student Services (12%)	34
Study Organization	Service Unit for Higher Education and Student Affairs (36%), Institutes (18%), Presidium (12%), Student Services (12%)	33
Addiction Counseling	Student Support Service (59%), Medical Services (25%)	32
Campus safety	Presidium (36%), Safety and Environment (30%)	33

Note: Due to lack of space, single mentions have not been displayed.

Furthermore, respondents were asked if there were any actors not included in this survey that they considered to play a significant role regarding students' health. 14 of the 35 respondents (40%) named at least one additional actor. The nominations are as follows: Facility Management (number of mentions: 6), General Services (4), Faculties (3), Conflict Management and Psychosocial Counseling (2), Student Councils (2), Service Unit for University Law and Academic Affairs (1), University Departments (1), Service Unit for Law (1), Adjunct Lecturers (1), Strategic Corporate Development and Communications (1), Canteen (1), Study Commission (1), Faculty Council (1), Physics Student Council (1), Social Club in the Student House (1), Center for Technology-Enhanced Learning (1), Representative for Refugees (1) and Vice-President for Higher Education and Student Affairs (1). Thus, 18 actors that were previously less in the focus of the participatory health promotion project but could play a meaningful role in improving students' health have been identified. Facility Management, General Services, and Faculties were mentioned by multiple respondents and are thus ideal targets for engagement efforts in the future.

Respondents were asked to rate their level of cooperation and communication with each actor from the list. Two network maps were generated from these variables for analysis. The first network map shows the cooperation-linkages (Fig. 2), and the second network map shows the communication linkages (Fig. 3). Reciprocity of the original dataset was ~0.5. Using the QAP procedure, there is a significant positive high correlation with $r=.85$ ($p<.05$) between the cooperation network with the communication network.

In terms of the cooperation network, 560 out of 1056 possible ties of the network were realized, resulting in a density of 0.53. Almost half of these ties (228, or 41%) suggested a cooperation level of information sharing only, while the other cooperation levels were as follows: informal cooperation (92, or 16%), formal cooperation (160, or 29%), and partnership (80, or 14%).

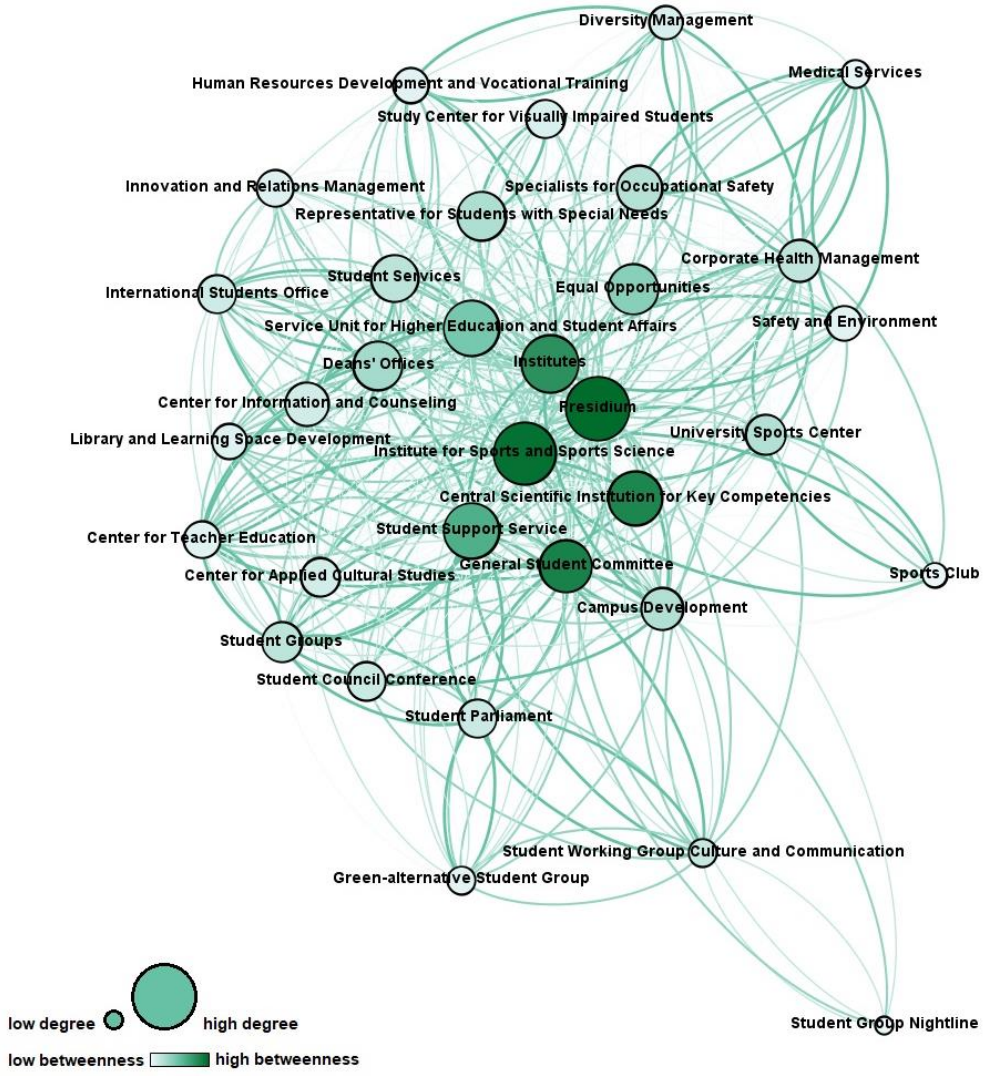

Figure 2: Cooperation network (node size represents degree centrality; node color represents betweenness centrality; link thickness and color represent intensity of cooperation)

Network measures for the cooperation network are reported in Table 3.

Table 3: Network Measures of the cooperation network (dichotomized data)

Measures	Cooperation network
Number of nodes	33
Number of ties	560
Average Degree	16.97
Degree Centralization	0.433
Density	0.53
Fragmentation	0
Average Distance	1.473
Standard Deviation Distance	0.507
Diameter	3

In terms of the communication network, 600 out of 1056 possible ties of the network were realized, resulting in a density of 0.57. 92 of these ties (15%) suggested a communication level of less than annually, while the other communication levels were as follows: annually (98, or 16%), half-yearly (202, or 34%), monthly (108, or 18%), weekly (74, or 12%), daily (16, or 3%).

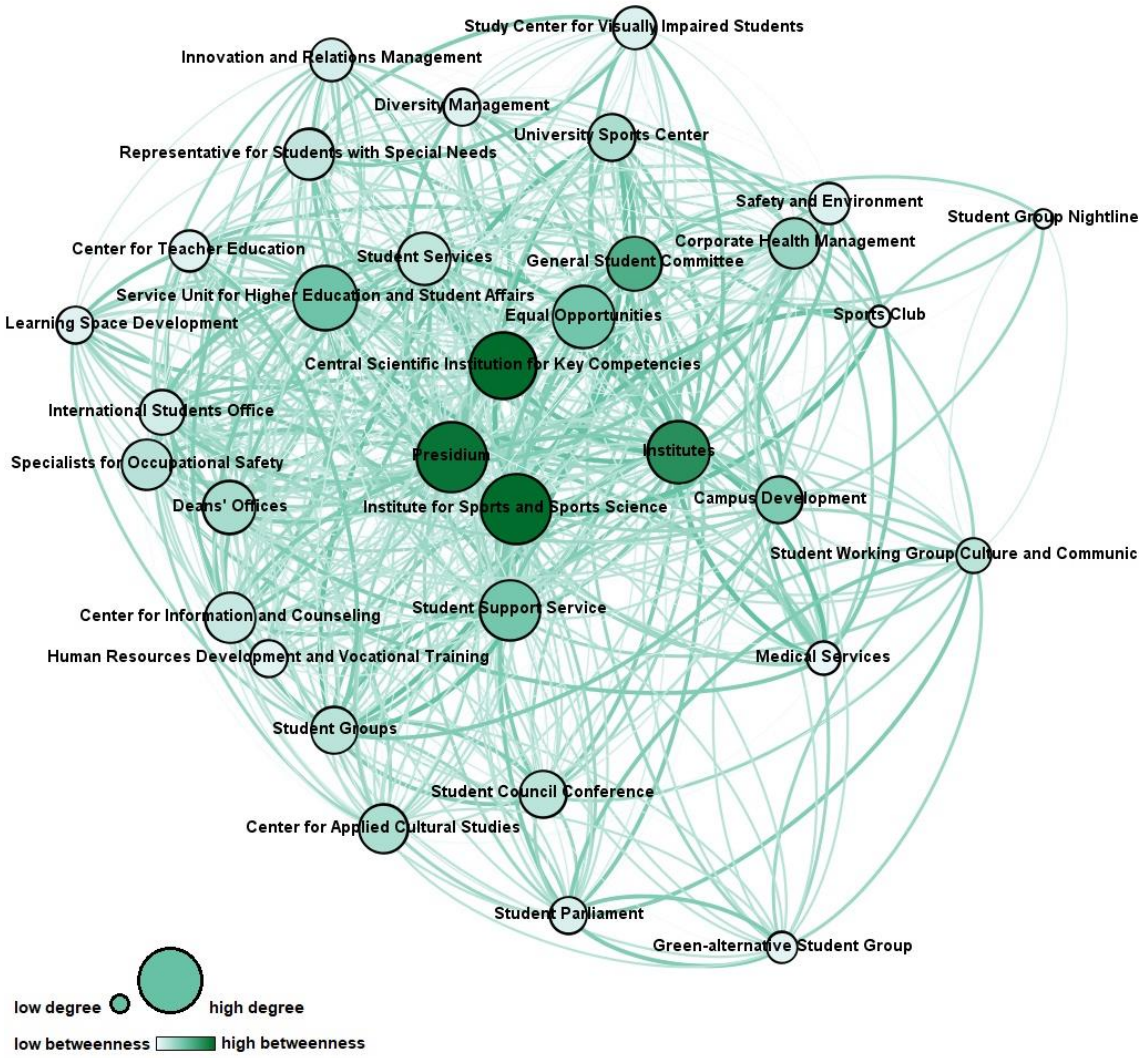

Figure 3: Communication network (node size represents degree centrality; node color represents betweenness centrality; link thickness and color represent frequency of contact)

Network measures for the communication network are reported in Table 4.

Table 4: Network Measures of the communication network (dichotomized data)

Measures	Communication network
Number of nodes	33
Number of ties	600
Average Degree	18.182
Degree Centralization	0.393
Density	0.568
Fragmentation	0
Average Distance	1.434
Standard Deviation Distance	0.499
Diameter	3

To identify key stakeholders in the original cooperation and communication networks following network structure constructs on actor level have been calculated (Cross & Prusak, 2002; Das et al., 2018; Freeman, 1979):

- Degree centrality: to explore who is a central connector by means of the number of ties an actor has with others and can be considered prestigious and influential
- Betweenness centrality: to explore who is a gatekeeper or information broker and connects various nodes in the network and therefore supports information exchange and has control over the network communication
- Closeness centrality: to explore who is an autonomous actor and therefore close to all other actors based on the distance between nodes so that he can spread information efficiently
- Eigenvector centrality: to explore who is a popular actor by means of the number of ties an actor has with other high-scoring actors concerning centrality

An overview of the scores for the most central actors can be found in Table 5.

Table 5: Overview of the network measure scores for the individual actors in the cooperation and communication network

Cooperation network	
most influential actors based on degree	1. Presidium (85), 2. Institute of Sports and Sports Science (71), 3. Institutes (65)
information brokers based on betweenness	1. Presidium (28.7) , 2. Institute of Sports and Sports Science (27.9), 3. General Student Committee (25.0)
most integrated actors based on closeness	1. Presidium (34), 2. Institute of Sports and Sports Science (35), 3. Institutes (38)
most popular actors based on eigenvector	1. Presidium (1), 2. Institute of Sports and Sports Science (0.86), 3. Institutes (0.79)
Communication network	
most influential actors based on degree	1. Presidium (114), 2. Institute of Sports and Sports Science (100), 3. Institutes (98)
information brokers based on betweenness	1. Central Key Qualification Facility (25.4), 2. Institute of Sports and Sports Science (25.3), 3. Presidium (24.2)
most integrated actors based on closeness	1. Presidium (34) and Institute of Sports and Sports Science (34), 3. Central Scientific Institution for Key Competencies (36)
most popular actors based on eigenvector	1. Presidium (1), 2. Institute of Sports and Sports Science (0.89), 3. Institutes (0.87)

To explore who is a *decentral specialist* providing specific knowledge, but is peripheral in the network, a comparison of the actors' legitimacy and competency attributions regarding students' health (see Tab. 1 & Tab. 2) with their centrality scores has been made. Medical Services, the Student Group Nightline, the Sports Club, the Specialists for Occupational Safety, and the Center for Information and Counseling were identified as such.

2.5 Discussion

Summary of main findings

The network analysis at hand provides in-depth insights into university structures promoting students' health comprising 33 organizational units and hundreds of ties. Both cooperation and communication network show a flat, non-hierarchical structure, which is typical for the university context (Hüther & Krücken, 2018).

This structure is reflected by its low centralization indices and short average distances with low standard deviations, indicating that every actor can be reached by every other actor via one to two nodes as a rule. The largest geodesic distance in the network, which is expressed by diameter, is small and with regard to fragmentation the networks show the non-existence of subgroups. Density, in other words the ratio of observed ties to the number of possible ties, is relatively high. It is assumed, that high density increases the probability, that weak ties turn into strong ties in the future (Kenis & Knoke, 2002). Every node is connected with more than half of the networks' nodes on average, what is expressed by average degrees. Due to the compactness and connectedness of the network, it can be assumed that information is likely to reach everyone in the network quickly. The pattern of linkages of the cooperation network suggests that the highest number of relations among the actors were for information sharing. This finding is consistent with previous research on public health networks, which shows that stakeholders tend to communicate rather than cooperate as this is associated with less effort (Provan et al., 2005). The cooperation network and the communication network are highly correlated ($r=.85$, $p<.05$), showing that these two networks are not independent of each other. Simultaneously the density of the cooperation network is less pronounced than the density of the communication network. This is in line with current research findings, which show that communication can be considered a precursor to cooperation (Robinson et al., 2015; Wäsche, 2020). From network analyses in other settings is furthermore known that actors tend to form ties with similar others because of the similar nature of work (Brownson et al., 2010; Buchthal et al., 2013). This phenomenon is called homophily (McPherson et al., 2001), and can partly be observed within the present network (e.g., interconnectedness of the student groups).

Interpretation of findings

Substantial cooperation between university actors with very different core agendas is needed for health promotion of university students (Dooris & Doherty, 2010a, 2010b). Since it is a young field of activity with an unclear role distribution, university units may have limited experience at cooperating in this regard. The present findings allow identifying starting points for effective network

development and governance in revealing key stakeholders as well as in discovering actors that should take on a significant role in the future process. Across the two networks, opportunities for further integration and interaction exist. According to the respondents, the University Sports Center, the Representative for Students with Special Needs, and the Corporate Health Management are among the most important actors regarding students' health. However, they only play a minor role in the cooperation and communication network thus far. Interestingly, four of the top 10 actors (see Tab. 1) have chosen sports and relaxation as the topic, which plays the most important role in their everyday professional lives, suggesting that this classic field of action of health promotion is of key importance in regard to promoting students' health. Still, the network actors cover all requested health-related topics, and it is noteworthy that topics, which constitute the core business of universities (e.g., key qualification and further education, study counseling and curriculum), are not considered unimportant in the context of health promotion for students, which opens the possibility to integrate the topic of health crosswise at the university. Concerning cross-linkage of actors who contribute to the same health-related topic, strong relationships should be established, so that the division of tasks can be clearly defined and synergies created. Except for the General Student Committee, student groups tend to be located on the periphery of the network with fewer ties than central actors. Looking to the future it will be important to find out under what circumstances it is desirable and achievable for them to be more integrated in order to ensure that they participate in the health promotion process and that their needs and requirements are adequately addressed. Besides, opportunities to strengthen the ties of decentral specialists are evident. The integration of distal nodes may lead to new insights and offers new input for the matter (Granovetter, 1983). Medical services, in particular, could take on a much more significant role with regard to student health in the future as part of the risk assessment of mental stress. Stakeholders from the participatory health promotion project for students (e.g., Presidium, Institute of Sport and Sports Science or Central Scientific Institution for Key Competencies) play an integral role in both networks. The data confirm that the project already operates with key stakeholders and suggest to continue engaging these actors in activities for health promotion. Presidium and Institute of Sport and Sports

Science are the most important actors in terms of the functionality in the network (see Tab. 5). The commitment of the presidium of a university, in particular, is regarded as a crucial factor for the success of health promotion efforts regarding students, and health-related disciplines can provide important impetus in the process (Suárez-Reyes & van den Broucke, 2016; Techniker Krankenkasse, 2019). Institutes should be involved in health promotion efforts in their position as multipliers with direct contact to all students. Besides, barriers to cooperation, for example bureaucracy, differing goals or agendas of units, lack of time, and previous experiences of working together, should be considered in the development of the health promotion network (Brownson et al., 2010; Buchthal et al., 2013). For example, formal agreements could be used to determine goals in advance and define responsibilities for cooperation in this way to prevent the fear of a loss of autonomy and an impoverishment of resources on the part of the individual actors.

Theoretical papers in the context of health-promoting universities recommend the creation of an organizational structure to coordinate all actions related to health (Suárez-Reyes & van den Broucke, 2016). While this is probably the first network that was analyzed this profoundly in the university setting on behalf of students‘ health, research from other fields allows concluding effective modes of network development and governance that can be applied in the context of a university. Goal-directed networks, such as the actor-network of health-promoting universities, require a certain form of governance to utilize the benefits of cooperation among stakeholders (Wäsche & Gerke, 2019). The network at hand shows characteristics of a “participant-governed” network, which is governed by virtually all involved units coordinating activities and making decisions (although stakeholders of the participatory health promotion project play a special role in it as a kind of “leading group”). Such networks are common in the field of health services to build community capacity (Provan & Kenis, 2007). However, thought could still be given to whether a change in the governance approach might be useful. In “lead organization-governed” networks, for example, the network is led and coordinated by a legitimized central actor trusted by others (Wäsche & Gerke, 2019). This form of governance also works with low commitment levels of the network

members and is best suited for a moderate number of involved actors. To increase the efficiency of the network, a “network administrative organization” can also be considered, where governance is carried out externally by an independent unit, which is specifically set up to govern the network only (Wäsche & Gerke, 2019). This approach best fits networks with moderate density and centralization, moderate to many network participants, and a moderately high goal consensus.

Limitations and transferability

The survey questions and response items may have limitations. For example, it may be challenging to rate the level of cooperation or communication with another organization on the whole. The reputational snowball sampling could have biased the boundary specification, and therefore the sample. Having two different key informants might have led to a different list of actors. In terms of validity, the survey included a question regarding additional actors, and the evaluation on this matter did not suggest that significant units were missing from the network sample, except for the Facility Management and General Services. Usual concerns about the use of informants, who may have only partial knowledge about the underlying issue, were not a concern in this study, since in general the units’ executive director or in some cases a more knowledgeable staff member has been interviewed. Anyway, a bias in reporting or from missing data is a possible limitation in network analysis with key informant interviews (Krauss et al., 2004). In particular, the consistent consideration of multiple actors from each unit could have had an impact on the results of the network analysis. Apart from that, certain actors could have been ruled out through a selection bias since isolated actors have no network at all (Winship & Mare, 1992). Reciprocity of the original dataset was ~0.5, reflecting uncertainty among respondents regarding the actual occurrence and magnitude of the relationships. The network analysis at hand included unconfirmed links, because using confirmed links only may underestimate the extent of cooperation (Friedman et al., 2007). Minimization as an often-used symmetrizing approach was used to resolve rating discordances between two actors in a dyad conservatively (Hanneman & Riddle, 2005). This first-time network analysis of health-promoting structures regarding students’ health at a university maps hundreds of actor ties and reflects the views of dozen units, but since the

analysis is limited to the health promotion network at one single university, generalizations based on the available data should be made with caution. However, the fact that administrative structures of universities are basically comparable, at least in Germany and in the European higher education area (Hochschulrektorenkonferenz, 2017; Seeber et al., 2015), allows for a transfer of the numerous indications for network development, such as:

- university executive board and health-related disciplines as key stakeholders
- crosswise intergration of health promotion via core-business-units of university
- utilizing the potential of subordinate stakeholders (e.g., *decentral specialists*)
- informed decision on network governance of the health-promoting network
- representation of student groups' participation via cooperation in the network
- academic stress as focal point within health promotion for university students

Future direction and conclusion

The present work has laid a foundation for future research, that could include a longitudinal evaluation of the network by collecting data once again with the inclusion of the additional actors identified by respondents. Thereby, assessment should be extended by meaningful constructs (e.g., funding flow or resource sharing) to gain deeper insight into the network and by structural contingencies (e.g., network goal consensus or trust) to predict the effectiveness of network governance. Network analysis can thereby represent a new form of structure evaluation in health promotion, in which the emphasis is less on simple counts of program activities and more on the documentation of structural changes (Krauss et al., 2004). Compared to other methods of identifying key stakeholders, network analysis is characterized by high validity and reliability as well as being time-consuming and resource-intensive (Valente & Pumpuang, 2007). On a final note, this form of data collection enables universities to profoundly analyze their health-

promoting structures, which is the basis for sustained network governance and development.

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3 Paper II: Analyzing Mechanisms of Interdisciplinary Cooperation

Slightly modified version of the submitted manuscript

Bachert, P., Wolbring, L., Hildebrand, C., Woll, A. & Wäsche, H. (under review). Analyzing Mechanisms of Interdisciplinary Cooperation in Promoting Students' Health at University. *BMC Public Health*

3.1 Abstract

Background: Interdisciplinary cooperation among university actors and resulting intersectoral synergies are considered cornerstones in the process of incorporating health promotion practices in everyday university life in order to break down barriers and provide better access to health promotion services. To date, no network of a health-promoting university has been examined regarding the underlying processes of tie formation, network emergence, and maintenance. *Objectives and methods*: The goal of this study is to obtain insight into the mechanisms of cooperation between university actors in a health-promoting network and to identify the structural and attributive factors associated to establishing cooperation between actors in the observed network in order to better understand how to build and develop successful networks in the future. For this purpose, a social network analysis was carried and out exponential random graph models were estimated to test corresponding hypotheses. *Results*: The network shows a flat, non-hierarchical structure. Data shows that attributed competence predicts cooperation. The structural predictors GWDSP, GWESP and GWDegree were positive and significant, and are therefore essential in determining the likelihood of cooperation between actors involved in the network. *Conclusion*: The results of this study can be used to further develop the network at hand and in addition, provide starting points for sustained network development at other universities. Knowing the factors that influence the network structure, here conditions of cooperation, provide opportunities to encourage empowerment among actors.

3.2 Introduction

Problem and relevance

University students are of particular relevance from a public health perspective (Stewart-Brown et al., 2000). Not only because they represent a considerable proportion of the population in need of health promotion, but especially because of their potential health-promoting multiplier role as future leaders, decision makers and parents (Dooris & Doherty, 2010a). The transition from secondary to tertiary education is a decisive moment causing substantial life changes and marking the transition from adolescence to adulthood (Aceijas et al., 2017). During this critical period of young adulthood, the behavioural habits in the years to come are formed (Haas et al., 2018).

University students face various stressors including general academics stressors and exams, lack of time, financial worries, uncertainty of plans after graduation expectations both from self and others, relationship problems and loneliness (Hurst et al., 2013). With regard to the state of health, despite their young age, different health problems like stress (Ribeiro et al., 2018), burnout (Kaggwa et al., 2021), depression (Ibrahim et al., 2013), overweight and obesity (Peltzer et al., 2014; Vadeboncoeur et al., 2015), back pain (Anggiat et al., 2018; Imdad, 2016), sleep disorders (Jahrami et al., 2020; Jiang et al., 2015; Li et al., 2018), and migraine (Wang et al., 2016) are common among university students. Apart from that, university students are vulnerable for engaging in risky health behaviors, for example alcohol consumption (Davoren et al., 2016; Karam et al., 2007; Wicki et al., 2010), unhealthy eating behaviour (Bernardo et al., 2017), physical inactivity (Irwin, 2004; Pengpid et al., 2015), sedentariness (Castro et al., 2020), smoking (Guerra et al., 2017; Patterson et al., 2004), use of other substances (Papazisis et al., 2018; Skidmore et al., 2016), internet addiction (Shao et al., 2018), suicidal thoughts and behaviours (Mortier et al., 2018), and inability to appropriately find, understand, evaluate, and apply health information to make health-related decisions (Kühn et al., 2022). COVID-19 may have exacerbated existing health issues and the impact of stressors evident prior to the outbreak (Vindegaard & Benros, 2020).

The literature available on health-promoting universities shows a wide range of approaches promoting modifiable health influencing factors of students (Dietz et al., 2020). Overall, interventions aiming at the individual level, as opposed to environmental-level interventions, are overrepresented (Dietz et al., 2020), likely because implementation and evaluation of environmental-level interventions are more complicated (Fernandez et al., 2016). Anyhow, state-of-the-art models for the explanation of health recognize that health goes beyond the individual level and is affected by environmental characteristics, for example at the organizational level (see socio-ecological frameworks from Burke et al., 2009; Stokols et al., 2003). These findings call for action in regard of innovative setting-based strategies to promote health of university students. Therefore, they confirm numerous voices in the field of health-promoting universities underlining the need for a whole-university approach that pays attention to the complex interactions and interconnections between component parts and highlights how the organization can function effectively as a social system (Dooris & Doherty, 2010b; Newton et al., 2016).

Interdisciplinary cooperation among university actors and resulting intersectoral synergies are considered cornerstones in the process of incorporating health promotion practices into everyday university life in order to break down barriers and provide better access to health promotion services (Dooris, 2001, 2006; Dooris et al., 2014; Dooris & Doherty, 2010a; Ewing et al., 2007; Sarmiento, 2017). Collective action by a wide range of stakeholders is essential for effective health promotion since a single stakeholder can hardly be in control over the complex interplay of multifaceted determinants of a targeted population's health (Batras et al., 2014; Poland et al., 2009; Woulfe et al., 2010). In their study on success factors for a health-promoting university Seibold et al. (2010) also conclude that it is beneficial if there is a well-connected group consisting of various key players working towards health promotion at university. *The Okanagan Charter: An International Charter for Health Promoting Universities and Colleges*, developed to guide health promotion within university settings, recommends working according to the *setting approach*. This means in concrete terms that relevant stakeholders from various disciplines and sectors within the campus community should be

cooperatively involved in the process of embedding health into all aspects of campus culture (e.g., curricula, teaching, research) and of providing health-promoting activities for students. Here, actors and organizations being only indirect involved with students' health should be included.

Partnerships offer multiple benefits, including information exchange, knowledge gain, building trust and increasing reach with the target population, access to and provision of additional resources, avoidance of duplicate structures, boost to innovation, possibility of achieving higher goals, opportunity of task sharing and pursuit of a holistic approach (Batras et al., 2014; Varda et al., 2008). Since universities are complex organizations, systematically navigating health promotion is necessary for it to be effective and efficient (Dooris et al., 2021). In contrast to traditional social science methods, social network analysis is uniquely suited to form the basis for this purpose by visualizing and describing relationships between actors as well as the overall network structure (Poghosyan et al., 2016; Wäsche et al., 2017; Wasserman & Faust, 2012).

State of research and research gap

In the past, various intra- and interorganizational public health networks were examined using social network analysis to visualize and examine structural characteristics and cooperation processes: active living (An et al., 2017; Buchthal et al., 2013), cancer support (McKinney et al., 1993; Ramanadhan et al., 2012), children's health initiatives (Mulroy, 1997; Valente et al., 2008), community care (Franco et al., 2015; Valente et al., 2010; Weiner & Alexander, 1998), elderly care (Bolland & Wilson, 1994; Kaluzny et al., 1998; Lang et al., 2005), HIV/AIDS service (Kwait et al., 2001), injury prevention and control (Harris et al., 2017), mental health services (Becker et al., 1998; Nakao et al., 1986; Provan & Milward, 1995; Tausig, 1987), physical activity promotion (Timm et al., 2021; Wäsche et al., 2021), prevention of diabetes (Provan et al., 2005), tobacco control (Fujimoto et al., 2009; Harris et al., 2008; Luke et al., 2010; Mueller et al., 2004), and women's health (Eisenberg & Swanson, 1996; Phillips, 1991).

A multi-methodical, but not network analytical, approach to map out and characterize health-promoting structures of a university was used by Sarmiento (2017).

Information on localization, resources, and partnerships of health promotion initiatives was collected via semi-structured interviews with stakeholders in health-related roles. Examination of partnerships, however, was limited, as is commonly the case in literature on health-promoting universities, to the naming of allied university actors (Ferreira et al., 2018; Suárez-Reyes & van den Broucke, 2016). However, in-depth information about structural characteristics of a network promoting health at university regarding students using social network analysis was presented for the first time by Bachert et al. (2021). By analyzing 33 university actors and hundreds of ties through a network analytical approach key-stakeholders were identified, network measures explored and starting points for network development designated. Despite this evidence, there is a research gap on health-promoting universities, since no corresponding network has been examined regarding the underlying processes of tie formation, network emergence, and maintenance so far.

Objective and hypotheses

Therefore, the purpose of this study is to obtain insight into the mechanisms of cooperation between university actors in a health-promoting network and to identify the structural and attributive factors associated to establishing cooperation between actors in the observed network. Subsequently, a better understanding of how to build and develop successful partnerships in the future will be obtained. Derived from this several hypotheses were tested, whether exogeneous (attributive) effects and specific endogenous (micro-structure) configurations occur more often than by chance within an observed network (see Tab. 6). While the structural effects represent self-organizing characteristics of the network, the actor attribute effects refer to characteristics of the actors.

Considering the fact that organizational characteristics (e.g., perception of the importance of being part of a network) can cause higher activity in creating cooperative relationships to others (Wäsche, 2015), it was hypothesized that there are significant activity effects in health-promoting networks at university.

- H1: Actors of health-promoting universities deemed competent regarding student health issues show a higher activity in forming cooperative ties.

- H2: Actors of health-promoting universities that consider student health issues to be important in general show a higher activity in forming cooperative ties.
- H3: Actors of health-promoting universities that are considered important regarding student health issues show a higher activity in forming cooperative ties.

Based on the principle of homophily, which states that interaction between similar actors occurs at a higher rate than between dissimilar actors (McPherson et al., 2001), it was hypothesized that there are significant homophily effects in health-promoting networks at university. It has been shown that the participation of students themselves (e.g., student groups or representative boards) is a crucial element in health-promoting networks at university (Gürster et al., 2021).

- H4a: Student actors of health-promoting universities form more cooperative ties among each other.
- H4b: University units of health-promoting universities form more cooperative ties among each other.

In social network analysis, two nodes are considered structurally equivalent if they are connected to the same actors in the network (Borgatti & Grosser, 2015). Because of the frequent occurrence of this process of network self-organization in different contexts, it was of interest whether this effect could also be observed in view of the available network data. Accordingly, it was tested if there are significant structural equivalence effects (GWDSP – geometrically weighted dyadwise shared partner, clustering) in health-promoting networks at university.

- H5: Actors of health-promoting universities form multiple 2-paths in the network.

Transitivity, the tendency for two nodes that share a cooperative tie to form complete triangles with other nodes in the network (Newman, 2001), is another common network phenomenon (Robins et al., 2012), whose likelihood of appearance can basically also be expected in health-promoting networks at university, where there is a tendency of actors to work in small group-like clusters (Sarmiento,

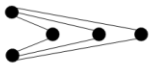
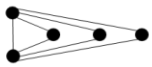
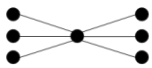
2017). Therefore, it was hypothesized that there are significant transitivity effects (GWESP – geometrically weighted edgewise shared partner, clustering) in health-promoting networks at university.

- H6: Actors of health-promoting universities form triplets of cooperation in the network.

Preferential attachement, or in other words the so-called mechanism of cumulative advantage, is a process often encountered in social networks (D'Souza et al., 2007; Schnegg et al., 2012). It can be assumed that the network at hand also shows this specific characteristic, because coordinating lead-actors are common in the field of health services (Provan & Kenis, 2007), especially in health-promoting universities (Bachert et al., 2021). Since GWDegree is a parameter that accounts for preferential avoidance (Hunter, 2007), a negative parameter value thus suggests centralization, meaning ties from low to high degree actors being more likely. Nodes with a higher degree commonly have a stronger ability to grab links added to the network (Robins, Snijders et al., 2007). Consequently, the hypothesis, that there are significant preferential attachment effects (GWDegree – geometrically weighted degree, centralization) in health-promoting networks at university, was formulated.

- H7: Actors of health-promoting universities form more cooperative ties to popular actors.

Table 6: Description of included parameters

Parameter	*Configuration*	*Description*
GWDSP		Models structural equivalence.
GWESP		Models transitivity.
GWDegree		Models preferential attachment.

Theoretical background and methodological approach

Network theory posits that actors do not work in isolation but instead are embedded in a system, why here their relationships among each other are in the foreground of consideration (Wasserman & Faust, 2012). Therefore, social network analysis is an effective method for dealing with relational data. The present network analysis falls into the research branch of *organizational network analysis* (Luke & Harris, 2007). An organization can be conceptualized as a network in which organizational members or units (consisting of the major representatives of those organizations for example) are nodes interacting with each other, establishing relationships (Brass et al., 2004). These networks between organizational actors are referred to as *intraorganizational networks*, as opposed to *interorganizational networks*, where the focus is on networks between different organizations (Baum, 2017; Wäsche et al., 2017).

ERGM (exponential random graph modeling) representa stochastic network modeling approach (Robins et al., 2007), which allows to predict the probability of a link between any two network nodes while accounting for the assumption that ties in a network are dependent on the presence or absence of other relationships (Harris, 2014). In order to test above listed hypotheses ERGM was applied, to identify attributes of actors, relationships and structure associated with cooperative relationships. From a mathematical point of view, ERGMs are probability distributions, modeling the probability that a relation between actors exist on the basis of a linear function of predictors (Wäsche, 2015):

$$P(X) = \frac{1}{\kappa(\theta)} exp\left(\sum_i \theta_i s_i(X)\right)$$

ERGMs explain the global pattern of an observed network (X), as a function of statistical parameters (θi) and local micro-configurations (si(X)). In turn, the probability of the observed network (X) is expressed as a function of the local micro-configurations si(X). A normalizing constant (κ(θ)) was included in the model formulation so that the probability of the observed network ranges between 0 and 1. Similar to regression, the observed network (X) represents the criteria, the local

micro-configurations (si(X)) represent the predictors, and the corresponding statistical parameters (θi) indicate the importance of the local micro-configurations (si(X)) in determining the global pattern of the observed network (P(X)). The local micro-configurations (si(X)) can both represent endogenous or exogenous micro-structures. The statistical parameters (θi) allow, by simultaneous consideration of other effects in the model, conclusions about whether the specific local micro-configurations si(X) occur more or less frequently in the observed network (X) than would be expected by chance. So, if a higher number of local micro-configurations (si(X)) in the observed network (X) are found than the expected number when ties are formed randomly, there is evidence of the significance of the local micro-configurations (si(X)) in explaining the global configuration of the observed network (X). Therefore, a positive (negative) local micro-configurations estimate (si(X)) suggests the presence of a greater (smaller) number of these configurations in the network than expected by chance, which provides evidence for (against) this particular mechanism associated with such configurations (Robins et al., 2007).

3.3 Methods

Measures

For the survey, a questionnaire was developed based on previous work on health-related networks (Brownson et al., 2010; Buchthal et al., 2013; Slonim et al., 2007; Wäsche, 2015). The quantitative relational construct measured among the university actors was cooperation, operationalized as the type of cooperation. For this question, a list of the 33 actors was provided. Respondents were asked how they would describe their relationship with each of the 33 actors. The cooperation response scale ranged from no cooperation (0); information sharing only (1); informal cooperation (loose cooperation to reach common objectives) (2); formal cooperation (close cooperation in a team to reach common objectives) (3); partnership (close cooperation for longer time period, e.g., in several projects) (4). Respondents were additionally asked about the relevance of the other actors regarding health topics, and the importance of the other actors regarding student health per se (on a five-point Likert scale from 1 = unimportant to 5 = very

important). Details on the questionnaire can be found in a recent publication from Bachert et al. (2021).

Sampling and data collection

Data were collected at a German university with more than 20.000 students. To identify all actors that address student health at the university at hand, a multifaceted snowball sampling process was initiated (Brownson et al., 2010; Buchthal et al., 2013; Guldbrandsson et al., 2012). This resulted in a final sample of 33 actors, who focus on understanding or promoting the health of students at university or who are potentially able to influence student health. More information on the setting, the sampling process and the sample is set out in the paper from Bachert et al. (2021). Organizational network data were collected during winter semester 2019/2020 by highly structured face-to-face interviews from trained research assistants using an interview guide in an interactive format with actor and health topic lists and response scale cards. The main representative of each of the 33 actors (generally the executive director or, in some cases, a staff member who was more knowledgeable about the issue) received a personalized interview request for this purpose, including a cover letter explaining the research study and a privacy statement. In the end, 28 out of 33 actors completed the survey providing an 85% response rate. Three of the 33 actors (Student Groups, Deaneries, and Institutes) represented a collective of various actors and were therefore not interviewed. The General Student Committee and the Student Working Group for Culture and Communication were not available for an interview. In total, 35 persons were interviewed, since the Institute of Sports and Sports Science (three respondents), the Central Scientific Institution for Key Competencies (five respondents), and the Student Support Service (two respondents) in their roles as central stakeholders in the context of student health had more than one respondent. Description of study approval and conduct can be read in the paper from Bachert et al. (2021).

Data processing

Survey data gathered through the questionnaire were entered to SPSS 25 Statistical Package by study ID for accuracy checking, cleaning and initial data

exploration on the basis of a codebook, before data from the network question were exported into Microsoft Excel for the creation of adjacency matrices. For the logistic models we dichotomized the cooperation variable as 0 = unlinked and information exchange only, and 1 = informal cooperation, formal cooperation, and partnership. Only informal cooperation, formal cooperation, and partnership were kept, as they reflect viable types of relationship between actors and tend to be more consistent. To reconcile divergent response pairs, two techniques were used in UCINET: reconstruction (when only one actor in the dyad provided a valid response to a question, response given by the other actor in the pair was used; (Huisman, 2014)) and symmetrizing (maximization was used to resolve rating discordances between two actors in a dyad). When both actors in the dyad did not give a valid response to a question, it was treated as a missing value – and therefore recoded to 0 –, which was the case for 20 (5 non-interviewed actors × 4) out of 1,056 ties, corresponding to a missing rate of <2% in the first case. If multiple respondents were interviewed from one unit or group, we used the responses given by the person highest in the hierarchy (Krauss et al., 2004).

Data analysis

For the descriptive procedures, data were analyzed in UCINET 6. For an analysis of structural cohesion at the network level, various measures of network cohesion were calculated (Luke & Harris, 2007; Poghosyan et al., 2016): average degree (average number of edges per node in the graph), centralization (extent to which the graph shows a centralized structure), density (number of existing ties divided by the number of possible ties), fragmentation (extent to which the network is broken into fragments of unconnected nodes, dyads, and cliques), average distance (average number of steps along the shortest paths (geodesics) for all possible pairs of network nodes), and diameter (largest geodesic distance in the network). The network map representing cooperation between actors was visualized using GEPHI 0.9.2. ERGM-analyses were performed with R version 4.1.2 (The R Foundation for Statistical Computing, https://www.r-project.org) using the statnet package.

We estimated the parameters of the exponential random graph model using Markov chain Monte Carlo (MCMC) methods. Model fit was assessed based on comparison of AIC and BIC scores throughout model development and goodness-of-fit statistics for common network distributions. Predictors were classified into two categories: structural predictors capturing aspects of local network structures and processes, as well as node attributes accounting for organizational characteristics of the individual network members. Three stages of model building were performed. Alpha was increased in each case until AIC und BIC had the lowest value.

First, a null model (model 0), which is a single parameter model without any predictor that assumes equal probability for all edges in the network (Goodreau, 2007), being essentially the network density, was created as baseline.

In a second step, organizational characteristics (type, importance, assessment of significance and competence) were added for model 1 as node attributes to capture their effects on the likelihood of cooperation between actors.

- *Type of actor* was a dichotomous variable that indicates whether an actor is a student actor or a university actor. Student actors were used as the reference category.
- *Attributed importance* was a continuous variable reflecting actors tending to be perceived as rather important vs. actors tending to be perceived as rather unimportant by the network with regard to student health. For this purpose, the rounded mean value on a five-point likert scale was used.
- *Assessment of significance of the health topics* was treated as a continuous variable. For this purpose, the mean value of all items on the basis of a five-point likert scale was included.
- *Attributed competence* is another dichotomous variable, which stands for the actors' perceived competence by the network. The decision as to whether someone was competent was made according to if an actor was deemed to be the competent in one of the thirteen health topics. Incompetent actors were used as the reference category.

Finally, model 2 was developed, which in addition to nodes' attributes and communication linkage also took structural patterns (preferential attachment, brokerage and transitivity) into account in explaining the cooperation behaviour between actors in order to uncover important aspects of network configuration. We included three commonly used geometrically weighted structural terms in model 2: GWDSP, GWESP and GWDegree (Hunter et al., 2008; Lusher et al., 2012).

3.4 Results

Descriptive analysis

The analyzed network consisted of 33 actors (see Tab. 7). 7 out of the 33 actors were student actors, while the remaining 26 actors were university actors.

Table 7: Network actors of the cooperation network

No.	Network actor
1	Student Working Group Culture and Communication
2	General Student Committee
3	Representative for Students with Special Needs
4	Library and Learning Space Development
5	Equal Opportunities
6	Service Unit for Higher Education and Student Affairs
7	Deans' Offices
8	Diversity Management
9	Specialists for Occupational Safety
10	Student Council Conference
11	Green-Alternative Student Group
12	University Sports Center
13	Central Scientific Institution for Key Competencies
14	Student Groups
15	Innovation and Relations Management
16	Institutes
17	Institute for Sports and Sports Science
18	International Students Office
19	Sports Club
20	Corporate Health Management
21	Medical Services
22	Student Group: Nightline
23	Human Resources Development and Vocational Training
24	Presidium
25	Student Services

26	Safety and Environment
27	Study Center for Visually Impaired Students
28	Student Parliament
29	Student Support Service
30	Center for Information and Counseling
31	Center for Teacher Education
32	Center for Applied Cultural Studies
33	Campus Development

566 out of 1,056 possible ties of the network were realized, resulting in a relatively high density of 0.54. The network shows a flat, non-hierarchical structure, which is typical for the university context (Hüther & Krücken, 2018). This structure is reflected by a low centralization (0.46) and a short average distance (1.46) with a low standard deviation (0.50), indicating that every actor can be reached by every other actor via one to two nodes. The largest geodesic distance in the network, which is expressed by diameter (2), is small and with regard to fragmentation the network shows the non-existence of subgroups. The average degree is 17.2, which means that every node is connected with more than half of the networks' nodes on average. Network measures for the cooperation network are reported in Table 8 and a visualization of the network is displayed in Figure 4.

Table 8: Network measures of the cooperation network

Measures	Cooperation network
Number of nodes	33
Number of ties	566
Average Degree	17.15
Degree Centralization	0.46
Density	0.54
Fragmentation	0
Average Distance	1.46
Standard Deviation Distance	0.50
Diameter	2

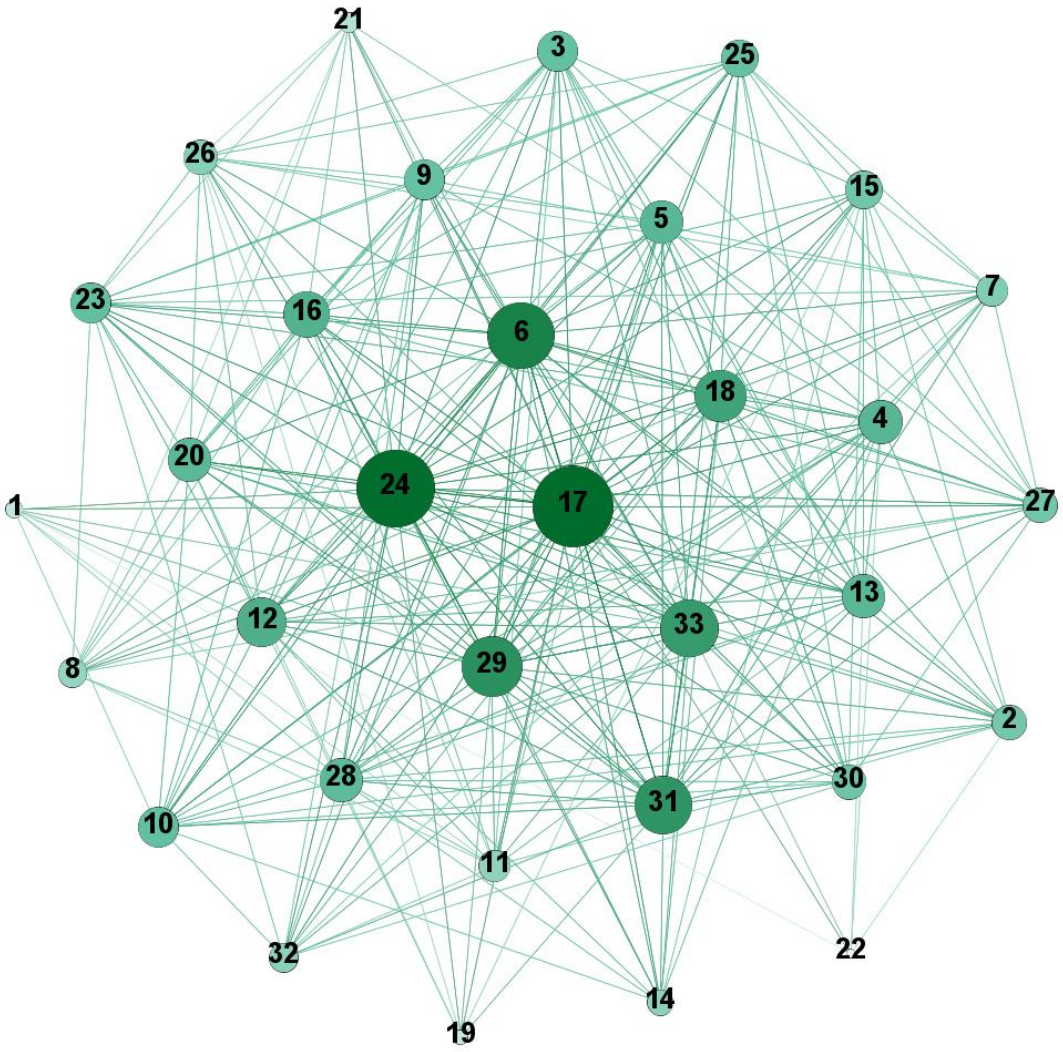


Figure 4: Cooperation network (node size represents degree centrality; node color represents eigenvector centrality)

Exponential random graph models

Goodness-of-fit-statistics, where the observed network was compared to numerous networks simulated from the model, showed sound model fit. The results of the estimated ERGM models are reported in Table 9.

The edge parameter, which describes the probability of a relationship taking into account the attributive and structural effects, is negative, since the existence of a relationship between two random actors is less likely than the absence of this

relationship, suggesting that fewer cooperation is realized in the network than would be expected by chance.

The significant positive estimate for attributed competence provides evidence for an activity effect – implying a higher activity in forming cooperative ties for competent actors. Hence, hypothesis 1 was confirmed.

The non-significant positive estimate for assessment of significance of the health topics provides no evidence for an activity effect – implying, that actors, that consider student health issues to be more important in general, show no higher activity in forming cooperative ties. Hypothesis 2 was disproved.

The non-significant negative estimate for attributed importance provides no evidence for an activity effect – implying, that actors, that are considered important with regard to student health, show no higher activity in forming cooperative ties. Hypothesis 3 was disproved.

The significant positive estimates for type of actor provide evidence for a homophily effect among student actors and among university actors, indicating that being from the same type appears to be a predictor for cooperation in the analyzed network. Hypotheses 4a and 4b were confirmed.

The significant positive estimate for GWDSP provides evidence for a structural equivalence effect – implying a tendency for clustering, that is, members of dyads in the network tend to share ties with the same sets of partners. Hypothesis 5 was confirmed.

The significant positive estimate for GWESP provides evidence for a transitivity effect – implying a tendency for path closure among the actors, which means that network members tend to form complete triangles with other network members. Hypothesis 6 was confirmed.

The significant positive estimate for GWDegree provides evidence for a preferential avoidance effect, rather than a preferential attachment effect – implying a tendency for a more even share of degree among actors. Hypothesis 7 was disproved.

Table 9: Stochastic models predicting the probability of cooperation between two actors in the network (* = p < 0.05)

	Model 0: Null model		Model 1: Attributive predictors		Model 2: Attributive and structural predictors	
Coefficient	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Cooperation (edges)	0.14	0.09	-2.81	1.55	-13.33*	3.86
Attributive predictors						
Student type of actor (homophily)			1.19*	0.48	1.31*	0.44
University unit type of actor (homophily)			0.83*	0.21	0.59*	0.18
Attributed importance (activity)			-0.02	0.14	-0.002	0.08
Assessment of significance of the health topics (activity)			0.26	0.14	0.11	0.10
Attributed competence (activity)			0.98*	0.18	0.32*	0.14
Structural predictors						
GWDSP (structural equivalence)					0.22*	0.07
GWESP (transitivity)					0.24*	0.07
GWDegree (centralization)					5.40*	2.48
Model fit						
AIC	731		667		732	
BIC	736		693		622	

3.5 Discussion

Summary of findings and interpretation

The aims of this study were to describe a university network for health promotion, to assess the likelihood of cooperation between the network's members and to identify the factors associated with cooperation. We analyzed data collected from 33 actors of a German university, who had established 566 relationships among themselves. The network is a high-density, decentralized network. Data shows that attributed competence predicts cooperation. Unexpectedly, attributed importance and assessment of significance of the health topics seemed not to be significantly associated to building cooperation. The structural predictors GWDSP, GWESP and GWDegree were positive and statistically significant, and are therefore essential in determining the likelihood of cooperation between

actors involved in the network. In other words, the actual appearance probabilities of multiple 2-path, path closure and alternating k-star were higher than that of a random level in the network, which means that cooperation does not happen by accident – there are this very antecedents, which drive the network in structure. The GWDegree effect can primarily be attributed to the interconnectendness of the vast majority of actors. The positive significant GWESP effect indicates, that cooperation in parts takes place in small triangular and trustworthy clusters, so that responsibility for the health of students can also be carried through this. Homophily effects are present among student actors and among university actors. Since student actors tend to cooperate with other student actors and university actors tend to cooperate with like actors, it is important to build more cooperative endeavors between these two types of actors.

Health promotion is focused on shaping the social preconditions of health. To a large extent these conditions are created by organizations for a lot of people, why targeted setting-based interventions are an important strategy. With respect to university students, this approach is complicated by their fluid membership status resulting in an unclear legal basis on the one hand. Young people take on different roles at university. They can be students as course participants and examinees, employees as student and research assistants, and customers when using certain university services. On the other hand, fluctuation among students is relatively high. Universities therefore face the challenge of sustainably promoting health and personal development within a relatively short time frame. In order to promote students' health more effectively the number of network members, the number of relationships or the intensity of existing relationships could be increased (Varda et al., 2008). According to the theoretical concept of *strength of weak ties*, intensification of existing weak ties leads to possible higher levels of diversity in the network while as per the theoretical concept of *structural holes* closing of gaps between actors, who have complementary sources to information, reduces redundancy by adding isolates to new other subgroups. However, these efforts can also lead to the following challenges (Glandon et al., 2021): increased interorganizational competition, time and resource investment with little benefit to members, worsening benefit-cost-ratio or reduced efficiency after reaching a

certain network size, network opposition and professional protectionism, ambiguity or uncertainty around accountability mechanisms, and coercion or manipulation of weaker network members by more powerful ones.

A certain form of network governance, in other words a conscious decision for the creation of an organizational structure to coordinate all actions related to the aims of a network, is required to utilize the benefits of cooperation among network members (Wäsche, 2019). The network at hand shows characteristics of a "participant-governed" network, which is governed by virtually all involved units coordinating activities and making decisions (although a handful of actors play a special role in it as a kind of "leading group"). Such networks are common in the field of health services to build community capacity (Provan & Kenis, 2007). However, thought could still be given to whether a change in the governance approach might be useful. In "lead organization-governed" networks, for example, the network is led and coordinated by a legitimized central actor trusted by others (Wäsche, 2019). This form of governance can certainly also be encountered in health-promoting universities and is considered advantageous by some experts (Seibold et al., 2010). It also works with low commitment levels of the network members and is best suited for a moderate number of involved actors. To increase the efficiency of the network, a "network administrative organization" can also be considered, where governance is carried out externally by an independent unit, which is specifically set up to govern the network only (Wäsche, 2019). This approach best fits networks with moderate density and centralization, moderate to many network participants, and a moderately high goal consensus. It should be noted that such an alliance of different actors, most of whom are not professionally involved in practical health promotion, may not be motivated to make an intensive, long-term commitment to promoting students' health. In addition, certain knowledge and skills need possibly to be developed, and proper moderation through intermediary units with spatial equipment, material and personnel resources is often required to enable effective health promotion.

Network development efforts are basically connectable to other highly regarded approaches in the field of health promotion like *community-based participatory research for health* (Wallerstein et al., 2018), in which equal cooperation between

professionals and recipients is a priority. *Capacity-building*, which postulates building infrastructure and cooperative partnerships for health promotion in organizations (Liberato et al., 2011) or the idea of *integrating health promotion services* to disseminate them more effectively through the network (Mays et al., 2010) are two more examples in this context. Anyway, change in an organization can only be embraced if actors can simultaneously rely on continuity (Paton et al., 2005). The focus of network development must therefore be on both: on what needs to be preserved (maintaining and enabling networks) and on what needs to be changed (further developing and stimulating new networks). Another crucial point is connecting health promotion to the original objectives of the organization and its actors (*health co-benefits*) to incorporate health as a goal and anchoring it. Referring to the university this means relating health promotion to teaching and research in order to support and maintain the health and promote the well-being of university students.

There are a number of ways to identify key actors and potential for development in a network, such as focus groups or knowledge mapping (Reed et al., 2009). Actor identifications generally pursue the questions of who is or should be involved, who is related to who, and who is influential. ERGM is furthermore able to answer the question of how the relationships are established in the first place. Moreover, the method of social network analysis can be used as an analysis as well as an intervention tool. Face-to-face interviews, in particular, are ideal for collecting network data while informing, raising awareness, and encouraging networking. However, social network analysis also involves numerous pitfalls, some of which are set out in the limitations section below.

Limitations and future direction

This study is the first to quantitatively examine a network for health promotion in a university setting using ERGM. Nonetheless it is a snapshot at one timepoint and comes with several limitations: The network boundary drawing and the chosen sampling process may bias the actors interviewed. The survey questions and response items may have limitations. A bias in reporting data is another possible limitation in this network analysis, since it is based on a single individual’s

interpretation of the interconnectedness of an organizational unit. Furthermore, the response behaviour was possibly characterized by social desirability. Future studies should avoid the limitations mentioned above, periodically track the network's evolution of cooperation to move closer to causal inference, and in the process particularly examine barriers and facilitators of cooperation.

Conclusion and Transferability

The results of this study provide an understanding of how a network promoting health a university is structured and which mechanism of cooperation are at work. However, the results cannot simply be generalized to other universities, but they can definitely be used to further develop the network at hand and in addition, provide starting points for sustained network development at other universities. Knowing the factors that influence the network structure, here conditions of cooperation, providee opportunities to encourage empowerment among actors available. In the future, it is conceivable that social network analysis will also take a place as a new form of structural evaluation in health promotion that, compared to traditional evaluation approaches, focuses less on simply counting program activities or mapping processes and more on documenting structural changes.

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4 Paper III: A Participatory Approach to Promote Physical Activity

Slightly modified version of the published paper

Bachert, P., Hildebrand, C., Erley, N., Jekauc, D., Wäsche, H., Kunkel, J. & Woll, A. (2021): Students on stairs: a participatory approach using decisional cues in the form of motivational signs to promote stair use, *Journal of American College Health*. https://doi.org/10.1080/07448481.2020.1845704

4.1 Abstract

Objective: The authors assessed whether an intervention using motivational signs designed in a participatory manner to promote stair use resulted in changes to the proportion of stair to elevator use. *Participants*: Students of a German university were observed in three different academic buildings. *Methods*: The study design consisted of direct observations during a pre-intervention period, an intervention phase introducing motivational signs promoting stair use at points of decision and a post-intervention period. *Results*: The proportion of students who took the stairs on average differed significantly between baseline and intervention phase I ($\chi 2(1) = 12.2$; $p = 0.001$; Phi = 0.078), baseline and intervention phase II ($\chi 2(1) = 17.3$; $p = 0.001$; Phi = 0.093), and baseline and post-intervention ($\chi 2(1) = 9.9$; $p = 0.002$; Phi = 0.074). *Conclusion*: Simple and cost-effective interventions can increase stair use of university students.

4.2 Introduction

Problem statement, relevance, and state of research

Physical inactivity and overweight are widespread among students (Rouse & Biddle, 2010). Global reports show that about 50% of university students do not meet the American College of Sports Medicine guidelines of accumulating thirty minutes or more of moderate-intensity physical activity on most, preferably all, days of the week, and that about 25% of university students are overweight or

obese (Peltzer et al., 2014; Irwin, 2004). One way to increase physical activity and energy expenditure is the incorporation of small amounts of physical activity into one's daily routine, which is effective especially for the inactive population (Pillay et al., 2009).

Considering the number of hours spent at university, the campus is an ideal setting to increase students' incidental physical activity. Incidental physical activity is any activity that is part of one's daily living that is not done with the purpose of recreation or health and requires no sacrifice of discretionary time (Stamatakis et al., 2019). Taking the stairs is an option to accumulate short bouts of physical activity throughout the day. Concerning regular physical activity, the barriers of incidental physical activity (e.g., extra time, scheduling, and money) are lower. The exact number of calories burned by taking the stairs varies depending on body weight, ascent vs. descent, and intensity at which stairs are taken (Ainsworth et al., 2011). Regardless, stair usage requires a multiple of the energy consumption of the resting state (Basset et al., 1997). For this reason, taking the stairs should be promoted as an advantageous alternative to the passive substitute via elevators. Stair interventions resulted in an increase of cardiovascular performance, muscle strength, and bone density, improved blood lipid profiles and body composition, reduced risk of osteoporosis and have been associated with loss of weight (Teh & Aziz, 2002; Boreham et al., 2005; Donath et al., 2014; Coupland et al., 1999; Boreham et al., 2000; Meyer et al., 2010; Zimring et al., 2005).

Reviews have shown that motivational signs placed at decision points between stairs and an escalator can increase the likelihood of people using stairs rather than taking elevators (Jennings et al., 2017; Bellicha et al., 2015). The vast majority of studies evaluated stair use interventions in public locations with virtually random passersby. Using these kinds of prompts on a university campus, ten out of eleven studies reported a significant increase in stair use. No previous work in the university setting has installed stair promotion signs developed in a participatory manner. In contrast to former research, this study focuses on students exclusively rather than employees. This study thus investigates the effect of motivational signs, which had been designed by the relevant target group and which

had been mounted at the point of decision between stairwells and elevators, on stair use of university students.

Theoretical background

The *Okanagan Charter for Health Promoting Universities and Colleges* (2015) calls for the creation of healthy campus environments and the strengthening of students' resources among other things – not only for immediate reasons of health promotion, but also due to the tertiary education setting being a sensitive phase for the cultivation of long-term health habits (Kwan et al., 2012; Nelson et al., 2008) and today's students being tomorrow's decision-makers in economy, education, public health, and politics (Staten et al., 2005). The socio-ecological model can serve as a starting point for theoretical considerations promoting physical activity among students (Sallis et al., 2008). It considers various determinants of human behavior on different levels, ranging from the policy to the intrapersonal level. On the individual level, social and psychological factors affect the implementation of health behavior. Targeting these behavioral influencing factors, decisional cues could encourage one's readiness to take health action through scraping the informational environment, and by doing so providing immediate information to an individual when it comes to deciding about different options for action (Lally et al., 2010). In this study, motivational signs were used as prompts to choose the stairs over the elevator to enhance physical activity. Studies have shown effects of decisional cues in regards to various health behaviors, including stair use behavior (Ford & Torok, 2008).

Purpose

The aim of this study was to assess whether an intervention using motivational signs designed in a participatory manner to promote stair use at points of decisions in university buildings results in changes to the proportion of stair to elevator use among students. The study additionally tested whether stair use remained at a higher level after the motivational signs had been removed and if selected factors predicted stair usage. Based on previous research, we hypothesized that (I.) the intervention would increase stair use among students, that (II.) increased stair

use could sustain beyond the removal of the signs, and that (III.) both building-related factors and situational factors would predict stair use.

4.3 Methods

Intervention

The intervention involved the placing of six different motivational signs next to elevators and stairwells on the ground floor in three different academic buildings of the natural and engineering sciences. The buildings were located on the same campus of a German university with a student enrolment over 25,000. All signs encouraged students to use the stairs as an alternative to the elevator. Messages on the signs included nudging statements focusing on environment protection, fitness and health, success, and time-saving (see Figure 5). The slogans were accompanied by suitable pictures as the strongest support in producing behavior change in this context was found for studies using a combination of text and images (Jennings et al., 2017). The colored signs in form of posters were 42.0 by 59.4 centimeters (approximately 16.5 by 23.4 inches) in size and framed in fire protection frameworks due to safety regulations. At each building, one sign was placed prominently at the point of decision, where the method of ascent is chosen (e.g., a pillar in front of and between stairwells and elevator). A second sign was positioned at eye-level right at the elevator. Intervention materials were put in place immediately after the baseline data collection in week 20 of 2018 and remained there for seven weeks. Signs were rotated biweekly. All modifications took place in agreement with the facility management, safety department, and office of construction. Due to the fact that every applicant for the university has to prove his German language skills at B1-Level (CEFR), the investigators used German messages only, except from an English quote from Zig Ziglar (“There is no elevator to success, you have to take the stairs.”).

Figure 5: Motivational signs created by the university students; Sign translation: Top left: Personal training: 50 €/hour – Fitness studio: 50 €/month – Taking the stairs: free of charge; Top right: Elevator. Pressing the button. I have to wait. It is just not coming. Stairs. (Slogan was written in the form of a poem.); Bottom left: The stairs are calling. Conquer them. (Reference to a German proverb.); Bottom mid: Be like Giuseppe. Take the stairs. (In German, Giuseppe rhymes with stairs.); Bottom right: Did you know that you could charge your smartphone every day of the semester with the energy of a single elevator ride?

Site selection

The department of civil engineering, department of mechanical engineering, and department of chemistry were chosen as intervention sites owing primarily to the proximity of the stairwell and the elevator within the buildings and the building

population being university students mainly. Additionally, the buildings represent the faculties with the highest number of students, which ensured a certain amount of traffic. The first flights of stairs experienced the most student circulation, due to the existence of lecture halls and seminar rooms on the first floor. Two of the buildings had eight floors, while the third building had seven floors. None of the sites required a key card to access the entrance. The number of elevators for all three buildings was two – right next to each other – while the number of stairwells on the first floor differed between one for the engineering departments and two for the chemistry department. All stairwells and elevators were clearly visible from the lobby, except for one of the two stairways in the chemistry department, which was slightly hidden. In all three observed buildings, stairwells and elevators were in close proximity and in visual range from each other. All stairways were in an adequate condition regarding preservation, lighting, and safety.

Study design and data collection

The time-series design of the quasi-experimental study consisted of observations of stair and elevator usage of university students during a pre-intervention period (calendar week (cw) 20 of 2018), an intervention phase introducing motivational signs promoting stair use at points of decision (cw 22 & 24 of 2018) and a post-intervention period (cw 28 of 2018). Trained research assistants made direct observations of the building population based on a standardized protocol. Prior to baseline data collection, practice observations were made to optimize inter-observer reliability between the research assistants. The total number of observations made during the four study phases was 4,265 (1,457 at the department of civil engineering, 1,680 at the department of mechanical engineering, and 1,128 at the department of chemistry). All observations took place inconspicuously on the ground-floor at each site, slightly away from the area of focus, but so that a direct view of the elevators and stairwells was maintained at all times. Observers recorded the number of people entering and leaving the stairwells and elevators with mechanic clickers as well as general information (date, time, etc.) and special events (hot weather, broken elevator, etc.) on a paper-based observation tool. For reasons of feasibility, the status of the observed persons (students vs. administrative and academic staff) was captured based on subjective estimations

by the research assistants based primarily on age and appearance. Observations were distributed during high and low traffic periods. High traffic was marked by the end of a lecture timeslot, the break in-between, and the beginning of the next lecture. Off-peak timeslots with no following lectures in the lecture halls were chosen for balance. Generally, at least two observers were present. For each site, observations were conducted on the same weekdays (on Monday, Tuesday, and Wednesday – primarily due to the presence of large teaching events on these days) and at the same time (09:15 a.m., 11:00 a.m., 3:15 p.m., and 5:00 p.m.) for a 45-minute observation phase. That is because similar behavior patterns can be expected at given times of a given day. Non-students (n=310), people carrying large or heavy objects (n=65), and those that appeared physically handicapped (n=2) were excluded from the study. All research was conducted in accordance with the Declaration of Helsinki and the ethical standards of the anonymous university. Since there was no means of identifying individuals, ethics approval was refrained from.

Participation

The intervention design was guided by a participatory health research approach (ICPHR, 2013). Firstly, students of a health-related course of studies were involved in site selection, the acquisition of general opinions of the target group on the use of stairs, and the selection of locations for sign placement within an undergraduate course in the winter semester of 2017/2018. Secondly, a focus group was conducted with students from the university during a one-week project management seminar in the course of key qualification acquisition in March 2018 to purposefully develop the intervention materials. By doing so, students from various study programs and who were not per se interested in health-related issues became involved in the process. Thusly, intervention material was designed from the perspective of students' everyday life and not through expert knowledge (e.g., consideration of behavior change techniques). In order not to influence the creative process, the course was not held by a health promotion expert and no examples of potential sign designs were provided to the group of students. The focus group discussions resulted in several important findings regarding layout, type of messages, and impressions of the signs (e.g., avoiding stigmatization of elevator

users), which were taken into consideration by the students themselves in the process of creating the motivational signs. A student assistant of the study team, who also works as a professional designer, converted the six signs into an appealing format. After that, interviews were conducted among students with special needs (e.g., walking impediment or visual impairment) to determine their perceptions around the prompts for stair use. Handicapped students did not feel left out looking at the signs, but pleaded for extensive and high-contrast signs, so that they were easily readable by wheelchair users and students with visual impairments. The signs were finally approved by the building administrators. While some of the signs created may not be typical health messages, unique forms of communication have been created through the participatory process that appeals to the priority population (e.g., a prompt in form of an elevenie (a short poem with a given pattern)).

Statistical Analysis

Baseline, intervention-phase, and post-intervention stair and elevator usage rates were calculated as well as relative changes for cross-site comparison. Preliminary analyses indicated that observations could be considered as independent. The Kolmogorov-Smirnov test revealed that data was normally distributed ($p>0.05$) and box plots showed no extreme outliers. Goodness-of-fit tests were used to test the effectiveness of the intervention. Logistic regression analyses were performed to examine the impact of the sign intervention and to assess which building-related factors (number of stairwells (1^{st} floor)) and situational factors (time of day (morning vs. afternoon), student traffic volume, and timeslots (follow lecture vs. no follow lecture)) predicted stair usage. These factors were chosen on the basis of previous research (Jennings et al., 2017; Bellicha et al., 2015). Analyses were performed using SPSS 24. A p-value ≤ 0.05 is considered significant.

4.4 Results

Descriptives

Across the four observation phases, all three buildings were accessible and stairwells and elevators were usable. Outstanding special events were not witnessed. The data collected during the test of the observation sheet in the chemistry building in the week before the baseline measurement was used as a control indication (stair use: 58.8%; not significant compared to baseline in chemistry building). Using cross-tabulation, there was a significant ($\chi^2(2) = 29.7$; $p = 0.001$; Phi = 0.175) variability in baseline stair use among the three departments (mechanical engineering: 66.3%, civil engineering: 46.2% and chemistry: 55.5%).

From pre-intervention to post-intervention relative stair use increased by 11.3% (absolute increase: 7.5%) for the department of mechanical engineering, by 15.2% (absolute increase: 7.0%) for the department of civil engineering and by 14.1% (absolute increase: 7.8%) for the department of chemistry. Figure 6 presents data on average stair usage across the sites regarding the four data collection phases.

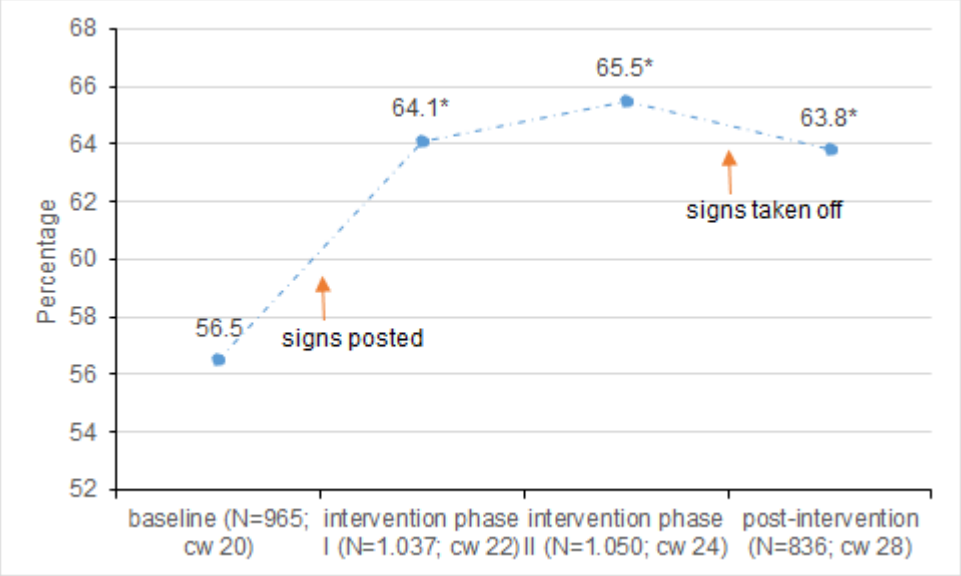

Figure 6. Average stair use of students regarding the four data collection periods; *Note: *: Increase in stair use compared to baseline is significant (p<0.002)*

Effectiveness of the intervention

The proportion of students who took the stairs on average differed significantly between baseline and intervention phase I ($\chi^2(1) = 12.2$; $p = 0.001$; Phi = 0.078), baseline and intervention phase II ($\chi^2(1) = 17.3$; $p = 0.001$; Phi = 0.093), and baseline and post-intervention ($\chi^2(1) = 9.9$; $p = 0.002$; Phi = 0.074). The Breslow-Day-test revealed that the adjusted odds ratio is legitimate ($p = 0.946$) for the comparison of pre- and post-intervention. The odds ratio of the Cochran-Mantel-Haenszel-test stratified by site ($\chi^2(1) = 10.1$; $p = 0.001$) was 1.376 (95%-CI: 1.133-1.669), indicating that there is a difference in stair usage at baseline and following times of measurement.

Impact of the determinants

The data shows that both the model ($\chi^2(5) = 151.91$, $p = .001$) and the individual coefficients of the variables, except for the number of stairwells (1st floor), are significant. The R-square according to Nagelkerke is .052, which corresponds to a medium effect. Factors that significantly predicted stair use were daytime (morning vs. afternoon), following lecture vs. no following lecture timeslot, student traffic, and pre-intervention vs. intervention. Results of the logistic regression analyses showed that stair use increased with the implementation of the intervention. This was also true for more student traffic. Stair use increased in the afternoon and decreased at off-peak timeslots, when there was no following lecture. The number of stairwells (1st floor) was not a significant factor in predicting stair use. The results indicate that odds of using the stairs increased by 37% from before intervention to intervention, and odds increased by 35% if it was afternoon and 33% decreased odds if it was off-peak time with no lecture afterward. If the traffic increased by one person, the relative probability of stair use increased by 0.5%. Table 10 presents the test statistics of the logistic regression model.

Table 10: Logistic regression model predicting stair use

	b	SE	df	p	ORs	95% CI lower	95% CI upper
daytime (morning vs. afternoon)	0,30	0,08	1	0,001	1,35	1,15	1,59
peak vs. off-peak timeslot	-0,40	0,09	1	0,001	0,67	0,56	0,80
student traffic	0,01	0,01	1	0.001	1,01	1,00	1,01
pre-intervention vs. intervention	0,32	0,08	1	0.001	1,37	1,18	1,60
number of stairwells (1st floor)	-0,11	0,10	1	0,238	0,89	0,74	1,08
constant	-0,03	0,39	1	0,941	0,97		
R^2=0.052 (Nagelkerke); model: $\chi 2(5) = 151.91$, p = .001							

4.5 Discussion

Summary of the findings

The primary aim of this study was to test the hypothesis that (I.) motivational signs which had been designed in a participatory manner and had then been mounted at points of decisions in university buildings increase stair use among students. The secondary aim of the study was to examine if (II.) this effect is sustainable over a certain period of time after the signs have been removed, and if (III.) both building-related and situational factors are predictors of stair usage. Our results supported Hypotheses I and II. For Hypothesis III, we could only find evidence for situational factors as predictors of stair use.

Findings in the context of existing literature

A recent study pointed out, that point-of-choice signs promoting physical activity might be a thing of the past, especially with respect to younger populations, who are used to being constantly stimulated (Engelen et al., 2017). In contrast, our findings showed that motivational signs based on a participatory health research approach can significantly increase stair use among students in university buildings. The results are in line with other studies. However, our outcome (mean stair use increase: approx. 7%) is slightly higher than outcomes of studies in the same setting (mean stair use increase: approx. 5%; Ford & Torok, 2008; Lee et al., 2012; Lewis & Eves, 2012) and other settings (mean stair use increase: approx.

4%; Bellicha et al., 2015). The baseline rates of stair use in this study (mean: 56%) were higher than in similar studies (on average: 32%; Ford & Torok, 2008; Lee et al., 2012; Lewis & Eves, 2012), substantiating the previous fact. High rates of stair use in the university setting may be due to the population's educational level and age, which is known as a determinant of stair use (Andersen et al., 1998). Stair use remained elevated after the signs had been removed, which is consistent with earlier research – in particular in workplaces, where the population is able to develop a routine in using stairs (Jennings et al., 2017). The university setting has a mix of employees and public population and therefore lies somewhat in the middle of the continuum from public to work site. Due to the particularities of the intervention, it can be assumed, that the student population of the present study consisted mostly of repeat audience. Results of the logistic regression showed that situational factors (time of day, student traffic, peak vs. off-peak timeslots) influenced stair usage. The number of stairwells (1st floor) in the building did not influence stair use. These findings are in line with previous findings where the time of day and pedestrian traffic levels showed to influence stair use (Lewis & Eves, 2012). It is obvious that the number of students is related to the availability of the elevators, which is limited to increased person traffic and during peak timeslots. A reason for stair use being higher in the afternoon could be that students are more likely to take the stairs when they have accumulated a certain amount of sedentary time during the process of their study day. Even though no statements can be made with regard to the effectiveness of single signs, recent research found that students prefer messages that emphasize the benefit of saving time when choosing to take the stairs over the elevator (Ly & Irwin, 2019). Preference for messages that emphasize productivity may be stirring from the fact, that time is a valued good among students, who likely focus on getting from lecture hall A to lecture hall B in a timely and efficient manner. One out of the six signs in this study aimed at time-saving. According to statements of the observers in this study, a lot of students also looked at and discussed the signs with the other messages, which every now and then tempted them to take the stairs. Students would probably also be attracted to interactive sign formats like questions and answers or challenges for fun reasons (Ly & Irwin, 2019).

Strengths, limitations, and future directions

The main strengths of this study are the comprehensive assessment of students' needs, the adequate theoretical foundation, and the detailed description of the underlying process steps of the intervention.

While some potentially relevant sociodemographic variables (e.g., weight status, ethnicity, physical activity level, or gender; Lewis & Eves, 2011; Webb et al., 2011; Bungum et al., 2007) had not been recorded, it is not possible to state, which subgroups of students benefitted most from the intervention. The predicting potentials of stair use direction (Kerr et al., 2001) and number of floors (Bungum et al., 2007), which is related to individuals' distance thresholds (Adams & White, 2002), were not considered. Adding these variables to the regression model could have increased its explained variance. Higher rates of intervention effectiveness could have been achieved with larger signs (Jennings et al., 2017), which could not be used because of safety regulations, illustrating that this study did not exploit its maximum potential. Due to the rotation system, it is not possible to make any statement about which of the motivational signs were the most effective. Anyway, the strongest support in producing behavior change in relevant previous research was found for studies using time- and fitness-based motivational prompts (Jennings et al., 2017). Inaccuracy in assessing student status and physical condition through observation and the missing of a true control building are also limitations of this study. Furthermore, observations were only conducted in the basement. The number of floors a student traversed is therefore unknown. Limitations came up mostly due to pragmatic reasons owing to a lack of resources.

Future studies should avoid stated limitations. It would especially be beneficial to record personal as well as sociodemographic variables (e.g., weight status, ethnicity, physical activity level, or gender) in order to investigate if there are any differences regarding the impact of the intervention on various subgroups. In addition, future studies could include a comparison of the various signs to see which one was more effective, use the signs in different types of buildings on campus (e.g., residential or administrative buildings vs. academic buildings) or test the

signs at other universities with different conditions. In-depth knowledge of the reasons why the stairwell or lift is used could help to make the intervention even more appropriate for the target group. For a more objective assessment of stair use, an automated motion-sensing tracking device is recommended. To be able to analyze longer-term effects, the collection of data for a longer time period would have been helpful. Acceptability and effectiveness of other potential ways of promoting stair use (e.g., LED-lamps on stair steps in combination with auditive elements or interactive formats on displays with gamification components) should be investigated, certainly with mixed-methods-designs in multiple intervention strategies. Generating suitable solutions for adding physical bouts in learning situations (e.g., during lectures or in the library) could also be the focus of future research.

Conclusion and practical implications

The present study shows that relatively simple and cost-effective interventions can increase physical activity of university students. The findings support the assumption that decisional cues can foster the formation of health behavior through an informational approach. The results moreover have implications for the development of interventions promoting stair use in general. The material of stair use interventions should be designed by the target audience in order to reach maximum effect. The concept of participation could be applied even further and enable the study population to engage in all phases of a project because it helps to gain a deeper understanding of the life-world and tailoring the intervention as a whole pursuant to the preferences and concerns of the appropriate population.

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5 Critical Reflection

The object of research of the present work was interdisciplinary cooperation among actors of a health-promoting university. A network-analytical approach was chosen to explore the organizational structures and to explain the underlying mechanisms of interdisciplinary cooperation among actors of a German university (see paper I & paper II). In addition, an environmental-level health intervention was carried out based on interdisciplinary cooperation of several university actors to promote physical activity among university students (see paper III).

In particular, it was shown that

- *Paper I*: the network at hand is flat and non-hierarchical, which is reflected by its low centralization indices and short average distances with low standard deviations, small diameter, the non-existence of subgroups, and a medium density. In addition, key actors in the context of student health, such as the University Sports Center, Presidium, and the Institute of Sports and Sports Science, were identified mainly based on network measure scores (Bachert et al., 2021a);
- *Paper II*: the likelihood of cooperation between actors involved in the network is determined by the micro-structural antecedents geometrically weighted dyad-wise shared partner (GWDSP), geometrically weighted edgewise shared partner (GWESP), and geometrically weighted degree (GWDegree). Moreover, it has been shown that attributed competence predicts cooperation, and homophily effects occur in the network concerning the actor type (Bachert et al., under review);
- *Paper III*: stair usage of university students can be sustainably promoted on campus site through point-of-decision prompts designed in a participatory manner including a cooperative effort by a wide range of university actors (Bachert et al., 2021b). In particular, the participation of the target group itself (university students) seems to be a success criterion.

The findings contribute to a better understanding of partnerships and intersectoral action in health promotion for students at university. Paper I provided first-time network-analytical insights into a health-promoting university that could not be readily exposed through conventional surveys and statistical analysis. Network analysis shows its strength when it comes to uncovering structural patterns (e.g., central and peripheral actors) and making them tangible through visualization procedure (Borgatti et al., 2009; Wäsche et al., 2017). In complement to network measures and visual representations for exploring and describing network structures, statistical modeling of networks is a technique for analyzing causes or antecedents of network emergence (Wäsche & Woll, 2013). Paper II is the first to quantitatively examine a network for health promotion in a university setting using exponential random graph models, a novel procedure within social network analysis (Robins et al., 2007). It thus provides knowledge for the first time about the mechanisms of network formation in a health-promoting university, which is of particular use for the development and management of networks. Paper III highlights the role of students themselves and provides answers to the specific question of whether an intervention using motivational signs designed in a participatory manner resulted in changes to the proportion of stair to elevator use among university students on campus site. Given the overall research question, it is shown that community-based participatory research (Wallerstein et al., 2018) is a solid approach to ensuring cooperation between university actors and promoting health.

However, some limitations, especially regarding the network analytical approach, must be considered when interpreting the results. There may have been a bias due to boundary specification. The selection of the actors to be included in the context of the network analysis is a central element, as it can strongly influence the results (Freeman et al., 2017). A meaningful narrowing is challenging and should be done primarily depending on the underlying research question. Despite the chosen multifaceted snowball sampling process, certain actors could have been ruled out since isolated actors have no relationships at all (Krauss et al., 2004; Winship & Mare, 1992). Furthermore, the information on cooperation was provided based on a single individual’s interpretation of the interconnectedness

of an organizational unit and social desirability could have played a role in the response behavior of the participants. Therefore, there is possibly a bias in reporting data. Although the response rate of 85% is relatively high (Borgatti et al., 2006), a bias due to missing values respectively unconfirmed links may have arisen due to the five non-responding actors.

However, the present network analysis provides in-depth insights into university structures promoting students' health, and since administrative structures of universities are generally comparable, at least in Germany and in the European higher education area (Seeber et al., 2015), data allows for a transfer of the numerous indications for network development in the context of health-promoting universities, such as:

- increase of number of network members or number of relationships and intensification of existing relationships
- members of university executive board and health-related disciplines as key stakeholders;
- crosswise integration of health promotion via *core-business*-units of university;
- utilizing the potential of subordinate stakeholders (e.g., *decentral specialists*);
- informed decision on network governance of the health-promoting network to increase the effectiveness of the network;
- representation of student groups' participation via cooperation in the network;
- academic stress as a focal point within health promotion for university students;
- selection of leading actors based on network measure scores;
- allocation of tasks, resources and responsibilities based on perceived expertise and responsibility;
- connecting health promotion to the original objectives of the organization and its actors (health co-benefits); and

- use of evidence about mechanisms of cooperation (e.g., homophily effects) to further develop the network.

Despite the numerous empirical innovations in the field of research of health-promoting universities, many questions remain unresolved. Several issues that are interesting for future research endeavors are presented subsequently.

Long-term studies, where the network's evolution of cooperation is periodically tracked, are required to move closer to causal conclusion. For example, stochastic actor-oriented models can be used to analyze network change and dynamics in longitudinal observations (Snijders et al., 2010), which allows the explanation of the outcomes of networks. Social network analysis in this way may emerge as a new form of structural evaluation in health promotion that, compared with traditional evaluation approaches, focuses less on simply counting program activities or mapping processes and more on documenting structural changes (Krauss et al., 2004). It may well be used in combination with qualitative analyses to increase the understanding of cooperation. Thereby, assessment should be extended by meaningful constructs (e.g., funding flow or resource sharing) to gain deeper insight into the network, and in the process particularly examine barriers and facilitators of cooperation. The following challenges have been identified in the past in cooperation networks: incompatibility of goals, competition, time and resource investment with little benefit to members, network opposition and professional protectionism, bureaucracy, ambiguity or uncertainty around accountability mechanisms, coercion or manipulation of weaker network members by more powerful ones, staffing turnover and loss of autonomy (Glandon et al., 2021; Hartman et al., 2018; Loitz et al., 2017).

So far, no statement can be made about the effectiveness of the network at hand. According to Provan and Kenis (2008) predictors, so-called structural contingencies, have to be considered with regard to the network structure to find out what strategy is needed to increase network effectiveness: distribution of trust throughout the network, the number of network participants, network goal consensus and the need for network level competencies. In the future, approaches to the effectiveness of the form of network governance should therefore also be investigated

(Wäsche, 2019). Moreover, network outcomes should be examined related to the maturity of the network, because they behave accordingly (McCullough et al., 2016; Provan et al., 2005). In the literature, six states of network maturity are described: searching, starting, development, maintenance, termination, and dormant (and re-activation) processes (Batonda & Perry, 2003; Meisel et al., 2014; Liberato et al., 2011).

From a theoretical perspective, there is a need to further elaborate the existing frameworks regarding the interplay of structural and behavioural factors, and the dynamic exchange between students and their environments (Dooris et al., 2014; Dooris, 2013) and to specify them to the point where recommendations for network development can be derived. Network research and development can be linked even more closely with change management, capacity building or other organization-related approaches in the future (Pelikan & Dietscher, 2015).

Last but not least, research on health-promoting universities would benefit from network analyses at various universities with different prerequisites (e.g., network governance) to build a body of research that allows for comparison and categorization. In this way, the buildup of knowledge on health-promoting networks at universities would enable a better understanding of network governance, development, and management for researchers and practitioners in the field of health-promoting universities.

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