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RESEARCH ARTICLE

Uncovering the Complexity of Care Networks – Towards a Taxonomy of Collaboration Complexity in Homecare

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Abstract. In homecare, networks are formed by professional, semiprofessional, and informal actors, who collaborate to care for people in need. Modern information and communication technology (ICT) might play an important role to enhance cooperation in homecare networks. Through infrastructuring work, the authors seek to build a comprehensive understanding of the types of collaboration complexity in homecare networks to determine if, when and which technologies are most suitable. This paper examines how homecare networks can be classified according to collaboration complexity. A four-stage research design was followed to develop a taxonomy for homecare collaboration. The taxonomy was applied to 21 care networks, and five types of homecare networks were identified. The taxonomy considers network, tasks, and communication particularities across 13 dimensions, each of which includes three characteristics. Three clusters were identified as more likely than the others to benefit from increased technology use. The taxonomy and archetypes highlight which homecare network types could benefit from increased technology use. Additionally, the taxonomy allows for an iterative re-evaluation of networks to initiate measures for improvement.

Keywords: Homecare networks, ICT, Infrastructuring work, Taxonomy development, Cluster analysis

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1 Introduction: The transformation of long-term care

The implications of assuming responsibility for a person in need of care is an omnipresent topic in the societies of developed countries. In the context of demographic changes, long-term care is undergoing a transformation. The need for care cannot be met by professional care and nursing homes to the same extent as in the past. Therefore, the importance of homecare that involves a large amount of self-care and informal care work is increasing. The societies' political objective is to enable self-determined aging in place, such that the person in need of care can be cared for and remain in his or her home for as long as possible. In European countries, long-term care is provided in a welfare mix (Theobald, 2012). The welfare mix approach assumes that societal sectors are present in the provision, funding and regulation of care (Theobald, 2012). Care is provided by informal actors such as relatives and friends, semi-professional actors such as neighborhood associations and professional actors such as nurses, doctors or pharmacies (Von Korff et al., 1997). However, European countries differ regarding the scope of each of these sectors (Theobald, 2012).

For example, Sweden has a well-developed system of long-term home care that is based on tax-funded and mainly publicly provided services (Meagher and Szebehely, 2013). Conversely, countries with more conservative welfare systems, such as Austria, Germany, Italy and Switzerland, rely on family caregiving.

In Germany, 68% of home care is provided solely by caring relatives, and 32% is provided in a collaborative work group of caring relatives and professional service providers (Statistisches Bundesamt, 2018). The main responsibility of elder care is assumed by close relatives (Schneekloth et al., 2017). Many family caregivers are not alone in caring for their relatives (Wetzstein et al., 2015): for about one-quarter of all people in need of home care, two relatives are involved in the care, and three or more people are involved in home care for another 31% (Schneekloth et al., 2017). More than two-thirds of primary caregivers are 55 years or older (55–64 years: 30%, 65–79 years: 28%, 80 years or older: 10%) (Schneekloth et al., 2017). Therefore, a considerable amount of homecare actors may require a certain degree of support in their own everyday lives. Thus, care and mutual assistance begin long before there is an actual "need for long-term care." Recently, concepts promoting solidarity and co-responsibility have increased in popularity (Klie, 2016). Citizens locally form networks to mutually support each other. In a constellation of "peer care" (Riche and Mackay, 2010), the distinction between givers and receivers of care becomes less clear, because everyone in the network gives and receives care as needed.

A second transformation in process relates to the role of technology in long-term care. Technology is expected to support all stages and settings of the elder care trajectory, from health promotion and self-care to technology-assisted homecare services and nursing homes (Woll and Bratteteig, 2019). As technology-supported care becomes increasingly important and accepted, the role of technology

in care collaborations between informal and formal homecare actors must be further investigated (Park et al., 2019).

In this paper, the authors examine the concept of care networks to uncover their complexity, specifically focusing on mixed-care collaboration (e.g., collaboration between formal and informal actors or human and non-human actors). Sections 2 and 3 present theoretical frameworks and review the related literature regarding informal care coordination and infrastructuring work in care. Section 4 presents related work regarding the complexity and diversity of homecare networks, which points to the necessity for further investigation and categorization of homecare networks. Section 5 presents the methodology for deriving categories of homecare collaboration and homecare network types, the results of which are presented in Section 6. Section 7 discusses the applicability of the taxonomy and the implications that can be drawn from the identified clusters. Finally, Section 8 concludes the paper.

2 Informal care work and (technology-supported) care coordination

A deep understanding of the diversity and complexity of formal and informal caregivers and their activities is necessary to guide the design of technical systems to support collaboration in care. Caregiving has been the focus of many studies in Computer Supported Cooperative Work (CSCW) and Human-Computer Interaction (HCI). Many of these studies were influenced or inspired by the work of Strauss and Star regarding ecologies of visible and invisible work, the importance of articulation work and the role of technology as a coordination mechanism in cooperative work (Strauss et al., 1985; Star and Strauss, 1999; Schmidt and Simone, 1996). Drawing on the earlier work of Corbin and Strauss (1985), Bratteteig and Eide (2017) identify seven types of work in home care, including information work, articulation work and relation work. Many studies have defined the nature of caregiving as cooperative work (Procter et al., 2014; Consolvo et al., 2004). Care cooperation has been described as the loosely coupled work of weakly tied teams across organizational boundaries (Granovetter, 1973; Pinelle and Gutwin, 2005). Primary caregivers not only bear the greatest burden of care work but also lead the articulation work (Tang et al., 2018). Typical challenges in this context include communication breakdowns, lack of transparency in the tasks and roles of actors in the care network, scheduling and temporal alignment of activities, coordination of handoffs, balance and fairness in task management, reconciliation of caregiving with work and life, trust building, easing of tensions among caregivers and dynamic changes in usual care arrangements (Schurgin et al., 2021; Tang et al., 2018; Renyi et al., 2017; Renyi et al., 2018; Renyi et al., 2019).

In a recent study, Abou Amsha et al. (2021) focus on the dynamic changes of fragmented, ad hoc collaboration in care. They draw on the concept of

knotworking (Engeström et al. 1999), which is defined as improvised collaboration in loosely connected groups (knots) depending on situational requirements. Knotworking is characterized by shared responsibilities, fluid roles and blurred boundaries. The results of this research, based on two design case studies in France and Denmark, indicate that home care can be considered a form of knotworking with distinct characteristics. A dynamic number of actors switch roles in a knot as the care process emerges, and there is no stable "gatekeeper" of collaboration. Collaboration occurs in episodes that can be predictable and unpredictable, and work arrangements in a knot are constantly negotiated. Amsha and colleagues propose the term "complex knotworking" to reflect these dynamics.

3 Infrastructuring work in collaborative home care

In this section, we discuss the concept of infrastructures and infrastructing work as theoretical framing and describe studies that have used an infrastructural lens to examine collaborative care. In a commonly cited study, Star and Ruhleder (1996) expanded the conventional understanding of (technical) infrastructures by emphasizing their relational and sociotechnical nature. Infrastructures emerge from their incorporation into organized practices. They are embedded in social structures, and they shape and are shaped by the practices of the people who use and maintain them. Infrastructures are often black boxes that invisibly support tasks and become visible only when they break down. As a sociomaterial arrangement, infrastructures dynamically evolve over time. The term "infrastructuring" is used to describe the process by which practices and artifacts become part of social and technological networks. This notion reflects the ongoing work that is needed to build and maintain infrastructures, including adoption and appropriation, articulation of breakdowns and repair.

Within the field of CSCW, numerous studies have addressed the role of infrastructures and infrastructuring work in (informal) care coordination, including in the context of medication (Bossen and Markussen, 2010; Danholt and Langstrup, 2012), chronic care (Langstrup, 2013), childcare (Gui and Chen, 2019), elder care (Schurgin et al., 2021) and mental health (Kaziunas et al., 2019). For example, Bossen and Markussen (2010) studied infrastructural breakdown during the upgrade of a medication module of a hospital information system, which revealed the module's role as an "ordering device" to facilitate and enable cooperative work. Gui and Chen (2019) studied the experiences of parents of young children trying to navigate a complex, fragmented healthcare system. Their results indicate that patients and informal caregivers encounter various barriers and breakdowns that result in infrastructuring work, including "repairing" unexpected failures at the individual level (e.g., missing clinical information), aligning components at the organizational level (e.g., failed coordination) and circumventing constraints (e.g., appointment waiting times). This work,

which ensures a functioning healthcare system, often remains invisible and unacknowledged. Unlike the infrastructuring work of professionals, the infrastructuring work of patients and informal caregivers is "temporary and ephemeral (…) without changing the healthcare infrastructure itself" (Gui and Chen, 2019). In a similar vein, Kaziunas et al. (2019) conducted an ethnographic study of behavioral health patients in the United States, and their findings highlight the "informal (and often invisible) practices people demand upon to manage their health needs." They argue that healthcare information systems, such as electronic health records (EHR) and care coordination systems, are developed to support professional work processes rather than to facilitate the everyday needs of patients, "leaving many important forms of collaborative care work overlooked."

Studies by HCI and CSCW have designed and evaluated numerous technology prototypes to support care cooperation, focusing on aspects such as activity awareness (Mynatt et al., 2001), communication support (Christensen and Grönvall, 2011), cross-organizational cooperation (Pinelle and Gutwin, 2002; Pinelle and Gutwin, 2005) and mobile services (Boessen et al., 2017; Drugbert et al., 2018; Goubran, 2017; Martinez et al., 2018; Bossen et al., 2013; Renyi et al., 2018; Abou Amsha et al., 2021). The results of these studies indicate that the needs and requirements of patients and informal caregivers are only partly addressed by existing healthcare information systems (e.g., patient records). According to an overview of commercially available solutions by Renyi et al. (2017), typical functionalities of existing healthcare information systems include a calendar view, management of appointments, contacts, tasks, medication and health information, as well as communication mechanisms such as messengers and notice boards. For some applications, download numbers indicate that these functionalities are rarely used in practice. The applications do not interface with the primary systems used by nursing service providers, which could present a significant obstacle to cooperation between professional and non-professional actors due to concern about double documentation (Renyi et al., 2017). Most research studies, like most commercially available systems, have concentrated on coordination in single-individual care networks (Renyi et al., 2020). Development of a suitable care mix and management of care structures have not been considered (Erickson et al., 2014; Renyi et al., 2017). Community networking platforms continually expand their range of functions and start to enable the establishment of individual care networks and mutual local support in a neighborhood.

4 The diversity and complexity of homecare networks

A better understanding of the complexity and diversity of care provision to older adults is needed to conceive effective technology solutions that support collaborative care (Procter et al., 2014). This includes a comprehensive understanding of the types of homecare networks defined by the care context, as well as the

involved actors, established practices and infrastructural arrangements. Several approaches have been used to classify networks. For example, Neumann (2014) separated care arrangements based on the care recipient's housing condition. Another approach is to characterize care networks by the care recipient's illness, like Neubert et al. (2020). They identified five types of family caregivers in networks for dementia patients. The presented types reflect the ways in which families approached dementia caregiving based on the interrelation between relationship quality and the distribution of caregiving tasks within the family. Broese van Groenou et al. (2016) identified four different network types among community-dwelling older adults with physical health impairments in the Netherlands. This study explored "how structural (size, composition) and functional features (contact and task overlap between formal and informal caregivers) contribute to different types of mixed care networks" (Broese van Groenou et al., 2016). In the study analysis, the researchers examine to what degree these network types are associated with care recipients' characteristics (Broese van Groenou et al., 2016).

In their study of the cooperative nature of informal elder caregiving in Latin America, based on qualitative interviews within four family networks, Gutierrez and Ochoa (2017) identified four roles of informal caregiving (assistant, monitor, helper and outsider). They found that gender, distance and affection to the care recipient had an impact on the caregiver's commitment to care and resulting role, and they also found that family members assumed implicit roles. Articulation work was found to be an expectation rather than an established practice. Tensions within the care network arose due to a lack of visibility of needs and caregiving activities and a lack of coordination, resulting in imbalance. None of the study participants had external professional assistance because formal caregiving services were rarely available, and there was little support from government services. In this regard, the study environment differs from the care situation in many Western countries.

The introduction of information and communication technology (ICT) into a homecare network as an active or passive actor can be considered as a complex intervention. The implementation and evaluation of complex interventions (i.e., interventions that include several components that may have interdependencies) in health care bring several well-known challenges (Craig et al., 2008). However, complexity is not only a characteristic of an intervention but a feature of the healthcare system itself (Hawe et al., 2009). Greenhalgh et al. (2017, 2018) have demonstrated that seven domains contribute to the complexity of interventions in the healthcare context: "the condition or illness, the technology, the value proposition, the adopter system (comprising professional staff, patient, and lay caregivers), the organization(s), the wider (institutional and societal) context, and the interaction and mutual adaptation between all these domains over time" (Greenhalgh et al., 2017). Regarding the implementation of collaboration technology into long-term care arrangements, the "adopter system" is the homecare

network. A deeper understanding of homecare networks could thus contribute to reducing the complexity of collaboration technology interventions for homecare networks (Renyi et al., 2020). As Park et al. (2019) have stated, care situations become analytically richer through an investigation of the concept of care networks. Additional knowledge about care networks could enhance the success of technology implementation, because it would enable fitting and helpful technology to be tailored to each network, therefore reducing the complexity of at least one domain. Due to "national differences in the availability of formal care, the care networks of older people may prove to be very different in other western societies" (Broese van Groenou et al., 2016); therefore, further research is necessary to "provide an indication of the relative importance of individual characteristics" (Broese van Groenou et al., 2016).

Grudin and Poltrock (2012) have stated that CSCW largely eschews theory building and experimental hypothesis testing. They also argue that many CSCW researchers are wary of fields such as Information Systems (IS), which rely on such approaches (Grudin and Poltrock, 2012). However, theoretical foundations are needed for this type of work (Correia et al., 2018). Theories such as classification schemes for homecare networks are necessary to guide care practitioners as they implement technology interventions and to enable researchers to choose an appropriate sample to address their research questions. Typologies improve the understanding and modeling of the complexities of homecare and therefore can contribute to theory development and assist in real-life care management simultaneously. Nickerson et al. (2013) have noted that the terms "classification scheme," "taxonomy" and "typology" are often used interchangeably in research, though "taxonomy" is the most commonly used of these terms (Doty and Glick, 1994). This paper therefore uses the term "taxonomy," which is defined as a set of dimensions, each of which consists of mutually exclusive and collectively exhaustive characteristics such that each object under consideration has one and only one characteristic for each dimension (Nickerson et al., 2013). This paper presents a concise, robust, comprehensive, extendable and explanatory taxonomy that will contribute "to order the disorderly concept" (Nickerson et al., 2013) of homecare networks and enable researchers and practitioners to structure and analyze this complex domain.

5 Research setting, cases and methods

To achieve this result, the timeframe of a single research project was insufficient. Therefore, this paper draws on the experiences and outcomes of our long-standing research interest in the domain of homecare work and collaboration. In a four-stage research design (see Fig. 1), homecare networks in the state of Baden-Württemberg in Germany were investigated.

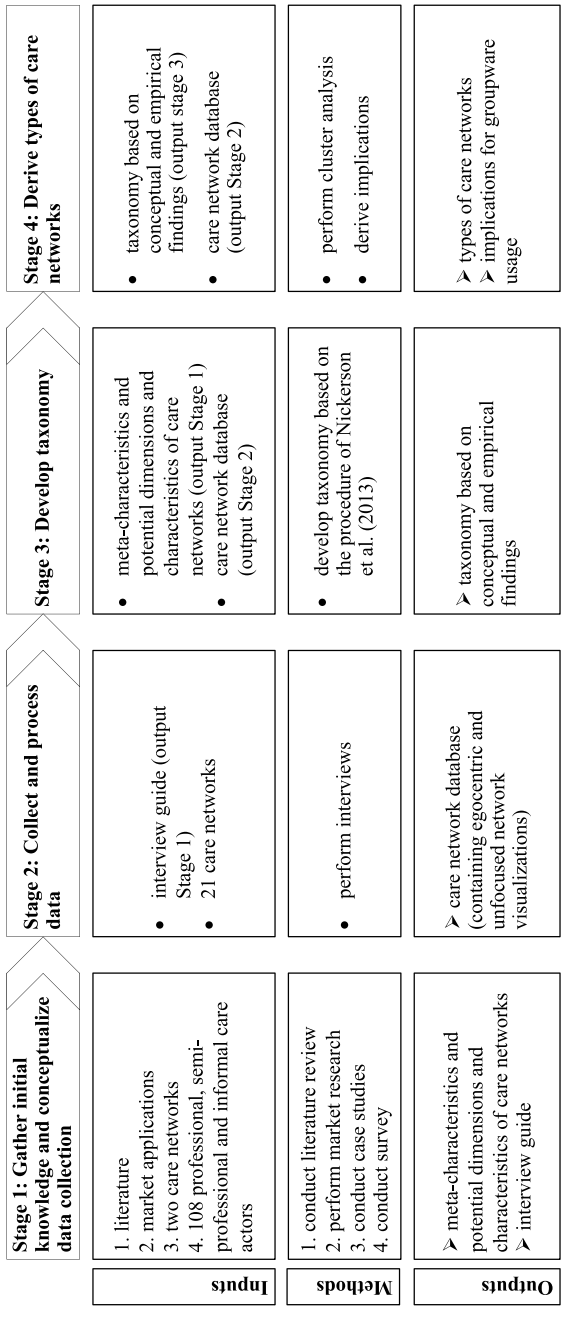


Figure 1. Research design.

5.1 Stage 1: Gather initial knowledge and conceptualize data collection

The first stage consisted of conducting several preliminary studies (Renyi et al., 2017, 2018, 2019, 2020), including reviewing publications and commercial applications, conducting two technology probe case studies with care networks, and surveying 108 professional, semi-professional and informal care actors. The results of Stage 1 were structured into potential dimensions and characteristics of care networks, and an interview guide was developed to collect detailed information regarding homecare networks (see Appendix 3).

5.2 Stage 2: Collect and process data

In Stage 2, structured (group) interviews were conducted between March 2018 and October 2019. The interviews lasted from 20–80 minutes (with a mean duration of approximately 40 minutes) and were led by one researcher, who moderated and documented the interview. Between 1–4 care actors of a network participated in the (group) interview. During the interview, interviewees were asked to report freely on their experiences in their care network. In total, data were gathered from 21 care networks, most of which were rurally situated. Twenty interviews occurred in person and one was conducted via telephone. The table in Appendix 7 presents the interviewees' characteristics, including age, caregiving role, and the number of caregivers in their network. Caregiving roles were delineated into three task fields[1]: (1) hands-on nursing and support, (2) coordination and organization, and (3) visits and care. The interviews were generally conducted with a small portion of actors in each network. In 18 of the 21 cases, the interview was conducted with persons involved in the task field "coordination and organization." In only three cases were the interviewees' primary activities in the area of "hands-on nursing and support."

In consideration of technical, material and situated circumstances, and using an infrastructure perspective on care (Danholt and Langstrup, 2012), we transformed the surveyed care networks into maps that visualized an overview of the entire network, including information regarding the number of participants, coordination structures and communication instruments (see Appendix 8). Rather than presuming which actors (e.g., patients, physicians, nurses) were central, we determined which actors managed homecare conditions and who was part of the infrastructure. Additionally, we visualized the data in an egocentric network presentation using the open-source software EgoNet[2]

[1] **hands-on nursing and support:** for example, providing domestic support, basic nursing, support for basic needs, craft activities, transport services; visiting service providers; accompanying patients to service providers; administering drugs; mobilizing care recipients; changing compression stockings, catheters and bandages**coordination and organization:** for example, organizing care or nursing activities**visits and care:** for example, visiting, providing psychological care (calls, conversation, etc.)

[2] http://www.pfeffer.at/egonet/

(Hollstein and Pfeffer, 2009) to form a network around the patient. The sectors of EgoNet were divided into the introduced task fields (see Appendix 9). The map and EgoNet representations of the data facilitated comparisons between the homecare networks.

5.3 Stage 3: Develop taxonomy

Based on the visualized data, a taxonomy was iteratively developed to characterize collaboration in homecare networks (see Fig. 2). In developing this taxonomy, we considered what a collaborating actor is and which of these actors influenced the collaboration needed to support the everyday life of a care recipient. According to Danholt and Langstrup (2012), everyone and everything that influences a care arrangement can be considered an actor. Accordingly, in the infrastructure survey, we included people, animals, technology and the living environment. To create a taxonomy for collaboration in care networks, we then applied a "magnifying glass" to focus on the analysis of actively collaborating actors. Technology can appear within the magnifying glass as an active professional actor in collaboration or outside it as a passive enabler of collaboration. The taxonomy reveals the current status of technology in a care arrangement and indicates whether changing the role of technology in the arrangement might reduce the complexity of the collaboration. Actors can be human or non-human; however, only an actor who can take on an active role in the coordination of tasks or communication with other actors is counted as a collaborating actor. The term "everyday collaboration" was defined as interactions that occur at least once per week. In some cases, all collaborating actors were considered when determining the characteristics of each dimension, whereas in other cases, only actors whose collaboration was necessary for everyday life were considered.

Networks emerge when there is a common goal that binds actors together. In homecare networks, the common goal is the optimal care of a person in need. Initially, *need of care* was included as a dimension of the taxonomy. However, this inclusion could lead to the incorrect assumption that higher need of care is automatically associated with higher complexity of collaboration in a care network. In the second iteration of the taxonomy development, it became clear that collaboration can be simple even when a high need of care exists. We therefore divided *need of care* into two dimensions, "stability of the care network" and "health status of the person in need of care." Further examination revealed that a person's health status also affects most other dimensions and therefore is not mutually exclusive. For example, the "frequency of needed consultations" may change with the person's health status because these changes may necessitate a different flow of information. In the following iteration, we deleted the dimension "health status of the person in need of care."

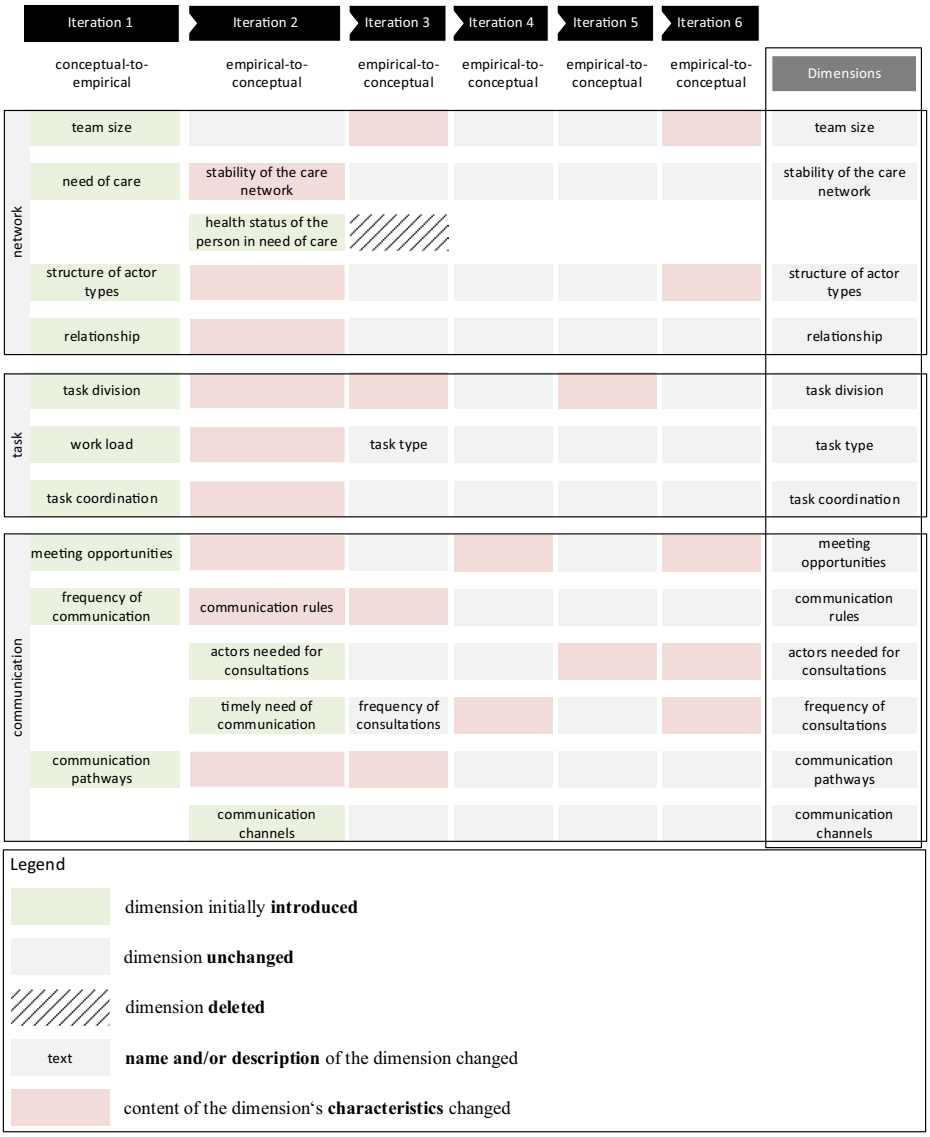


Figure 2. Visualization of Stage 3 – development of dimensions and characteristics for the taxonomy in six iterations (adapted from Kutzner et al., 2019 and Vogel et al., 2020).

5.4 Stage 4: Derive types of care networks

Kaufman and Rousseeuw (2005) state, that "[cluster] analysis is the increasingly important and practical subject of finding groupings in data." In the final stage of this project, we performed a cluster analysis to identify types of homecare networks using the Ward method (Hierarchical Cluster Analysis, n.d.). We used the

collected networks as items and the set of characteristics based on the taxonomy as clustering variables. In the iterative calculation, determining the distances between the clusters, a graphical dendrogram was processed (Stehlik-Barry and Babinec, 2017). The calculation starts with each network forming its own cluster. With each iteration, the most similar networks are joined into a single new cluster. The distance at which most clusters are distributed, determines the likeliest number of clusters. Within the processed dendrogram, most of the clusters lie on the same line at distance 4, which suggests the existence of six clusters. In examining these six clusters, two were similar to one another and differed only in the variable "structure of actors." This difference does exist, and the characteristic is complex. However, the number of professional actors in these two clusters was quite small. Therefore, a five-cluster solution was ultimately utilized (see Fig. 3).

6 Results

This section presents a descriptive summary of the surveyed networks, the taxonomy of collaboration complexity in homecare networks, the derived types of care networks and their potential for technology use.

6.1 Surveyed infrastructure

6.1.1 Recorded network actors

- Care recipient

Most care recipients were older than 70 years. One care recipient was in the age range of 0–30 years, and one was in the age range of 30–70 years. One case was a couple in need of support. Of the care recipients, 41% were male and 59% were female. A high need of care was not an inclusion criterion; however, 17 of the 22 care recipients had a certified need of care. Their needs ranged from minor impairment of independence to severe impairment of independence with special requirements for nursing care. The limitations and required support services were varied; however, transport services and escort to (health) service providers were recorded as universal needs.

In networks in which the person in need was not certified or had only minor impairment of independence, the person in need was usually the main person responsible for organizing their support. In networks in which the person in need of support was certified for a high need of care due to severe impairments, the organizational task was always assigned to persons other than the person in need of care. In 75% of cases, one person had primary organizational responsibility. There were constellations of shared responsibility in the remaining 25% of cases.

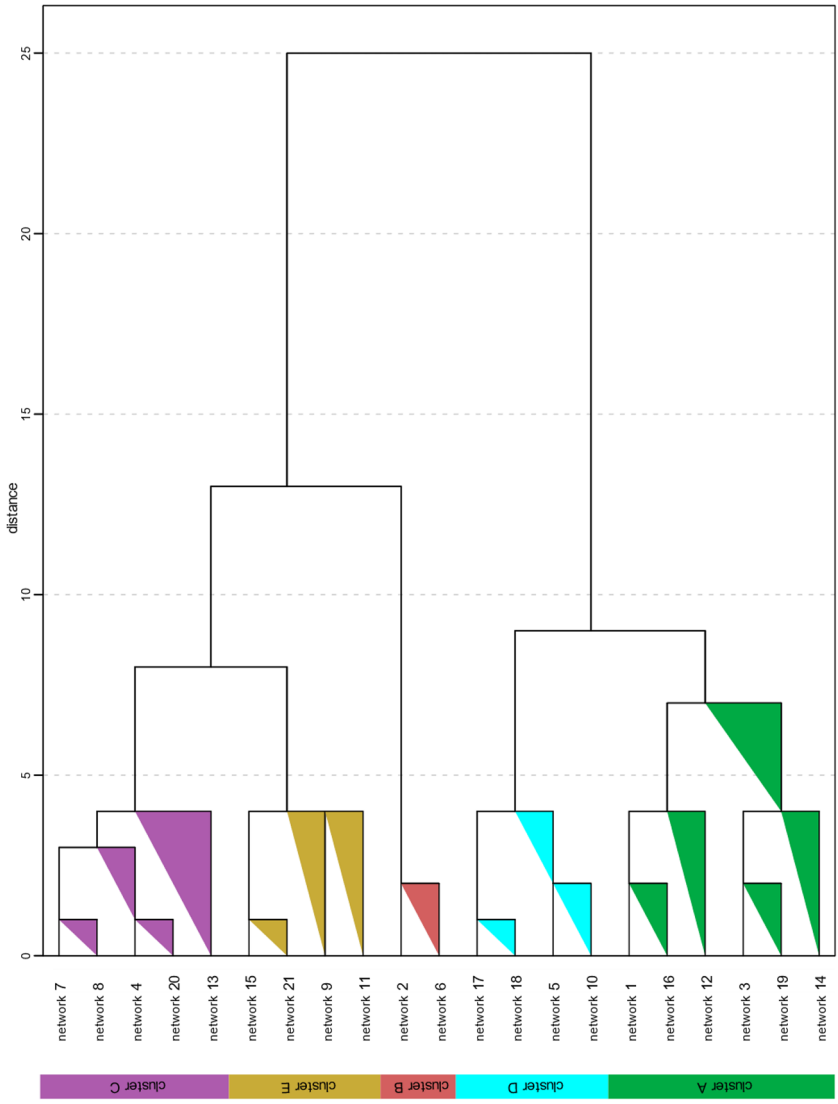


Figure 3. Dendrogram of the cluster analysis using the Ward linkage; the chosen clusters are highlighted in color.

- Caregivers

Interviewees often initially declared that they were the primary and sole person responsible for caring for a care recipient; however, during the interviews, it became apparent that the interviewees were not “alone” in providing care. None of the studied networks consisted of only one person supporting a person in need. In 65% of cases, 2–4 actors supported the person in need of care in everyday life, and in 35% of cases, at least 5 actors supported the person in need of care. In 11 cases, the support actors were a complete mix of actor types; in seven cases, a combination of professional and informal caregivers; in one case, a combination of semiprofessional and informal caregivers; and in two cases, solely informal caregivers. In a representative study by Schneekloth et al. (2017), the authors assumed that more than 50% of those in need of care were supported by at least two relatives; in this (non-representative) study, the proportion is notably higher. In only 25% of cases did a network include only one caring relative.

In 38% of cases, the burden of responsibility lay primarily with the (informal) main care organizer. In only one case was the professional service provider the primary actor responsible for coordinating and organizing tasks (as well as caring and nursing). In the other cases, the organizational tasks were shared between several actors or were primarily conducted by the care recipients themselves. In no case did semiprofessionals (such as neighborhood helpers) take on the sole role of coordinating and organizing tasks. Neighborhood help managers did not function as case managers supporting the coordination of the care network; rather, they primarily functioned as coordinators for the neighborhood helpers. The concept of the "community nurse" (Marks, 2019) — a “nurse” who conducts geriatric (and other) assessments, cares for the chronically ill, monitors and controls the medication regime, ensures adherence to treatment paths and gives advice — was not observed in any network.

6.1.2 Technology use

Personal and telephone communication were predominant in all networks and were the preferred forms of communication among most of the actors. Nevertheless, in 75% of networks, digital technologies were used to support everyday life. The decisions to use digital technology were mostly unconscious among informal caregivers, whereas professional actors were more likely to consciously use care-specific collaboration tools.

Informal actors used technologies that they already used to organize other areas of their lives. Applications with the “care label” had rarely been purchased and tried. Examples of the technologies used by informal caregivers include a reminder system, a GPS tracker and a home emergency call button. A baby monitor was used in one case because of its simplicity and wide availability. The reminder system incorporated into the everyday life of one care network had led

to relief. The care-specific applications of the GPS tracker and the home emergency call button were only used for a limited time. They were reported to be too singular in their functional scope, and they required additional effort to use, as well as the active participation of the care recipient. Thus, these technologies did not fit into the daily routine of care, nor did they offer functionalities that provided added value outside of emergency situations.

In contrast, the conscious decisions by professional actors to use care-specific digital aids are likely attributable to two reasons: legal certainty and (process) optimization. In the context of nursing care, sensitive health-related data are often shared. The protection of these data is not only desirable but also enforced by various legal regulations. For data protection reasons, professional actors are therefore unable to use the "everyday tools" used by informal actors. To achieve maximum optimization of work processes, systems that are adapted to specific care processes are also preferable to these "everyday tools." For example, professional actors used platform applications that supported the entire intra-organizational work process (i.e., documentation, communication and organization).

6.1.3 Communication and collaboration in the networks

Most networks had a good climate of cooperation. The interviewees stated that the coordination of tasks and appointments usually went well. Some interviewees mentioned that doctors were difficult to access and associated with scheduling problems. Regular in-network exchanges regarding care-specific topics rarely occurred. Professional and semi-professional actors discussed the case but informal actors were not involved in these discussions. One interviewee explicitly stated that she wanted to take part in the interview because there were tensions in communication in the care network, mainly among the informal actors. She hoped that she would be able to reduce tensions and increase transparency by participating in the field test[3] later. Another interviewee stated that she could imagine that the use of collaboration software would result in relief of the care burden in the network she supported, because there were tensions among the actors and a lack of appreciation for each other's work.

6.2 Taxonomy for collaboration complexity in homecare networks

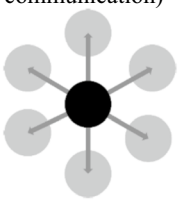
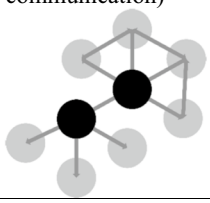
Other studies of care networks have focused on the actor types, the disease, or the care needs; however, this taxonomy is focused on collaboration within the networks. It is important to understand how networks are organized, how information is exchanged between actors and how tasks are distributed. These characteristics determine whether technology might offer added value and for

[3] Interview participants were offered the possibility to try out a research prototype for supporting collaboration in care networks.

Table 1. Domains and characteristics determining the complexity of collaboration in home-care networks.

		Collaboration is …		
	Regarding dimension …:	**less complex if ...**	**more complex if …**	**highly complex if …**
NETWORK	**team size**	just one actor supports the care recipient in everyday care.	few (two to four) actors support the care recipient in everyday care.	many (more than four) actors support the care recipient in everyday care.
	stability	the network of actors is stable. Stable networks exist for a long time and are supported by reliable actors.	there is a low fluctuation of reliable actors in the network.	the network is unstable (e.g., a network that is in the process of being established). Actors are constantly changing or are unreliable. Therefore, the rules of collaboration are constantly changing too.
	actor types	only one type of actor (informal or semi-professional or professional) is involved in the care network.	two types of actors ("informal and semi-professional" or "semi-professional and professional" or "informal and professional") are involved in the care network.	all types of actors (informal, semi-professional and professional) are involved in the care network.
	relationship	there are no tensions between actors.	there are tensions between some actors.	there are tensions between the majority of the actors.
TASK	**task division**	tasks are not interdependent and are clearly separated between actors.	several actors share the same tasks.	there is no clear separation of tasks between people; everyone does everything.
	task type	one actor organizes and carries out the everyday care.	one actor organizes everyday care, but multiple actors carry it out.	organization and conduction of everyday care are split between multiple actors.
	task coordination	one actor is responsible for coordinating all everyday tasks (regardless if this actor is professional, semi-professional,	several actors are responsible for coordinating all everyday tasks.	no one is responsible for coordinating the everyday tasks and everyone acts situationally.

Table 1. (continued)

		informal or the care recipient).		
COMMUNICATION	**meeting opportunities**	all everyday actors live or practice in the same house or on the same site and often meet by chance.	all everyday actors live or practice in the same district or area and therefore it is possible that they will meet by chance.	all everyday actors live or practice in different districts or area and therefore there is no possibility that they will meet by chance.
	communication rules	there are fixed rituals regarding communication about care (such as weekly team meetings).	there are rules regarding communication about care, but they are not strictly adhered to.	there are no rules regarding communication about care.
	actors needed for consultations	consultations are only necessary between two actors.	consultations are necessary between a few (three or four) actors.	consultations are necessary between many (more than four) actors.
	frequency of consultations	consultations are needed less than once per month.	consultations are needed between once per week and once per month.	consultations are needed several times per week.
	communication pathways	communication is steered by one actor who is in charge. (star-shape communication) 	communication is separated between actors depending on the topic. (separate communication) 	all actors must speak with one another to receive all necessary information. (meshed communication) 
	communication channels	all actors communicate via the same communication channel/medium.	there are multiple clear communication channels/media.	there are no rules regarding communication channels/media.

what purpose it should be used. The developed taxonomy contains 13 dimensions, each of which has three distinct characteristics (see Table 1). The purpose of the taxonomy is to support the understanding of the complexity of collaboration in homecare; thus, the characteristics are to be understood as "Regarding dimension X: Collaboration in care networks is less, more, or highly complex if …." For example, the first characteristic states, "Regarding

Figure 4. Visualization of the defining features of the clusters and their differences; less complex: green + 1; more complex: yellow + 2; highly complex: red + 3.

cluster	team size	stability	actor types	relationship	task division	task type	task coordination	meeting opportunities	communication rules	actors needed for consultations	frequency of consultations	ways of communication	communication channels
A			1				1						2
B		1		2	1	2		2		2	3	2	3
C		1			2	3	2		3			2	2
D	2			1	1		1		1	1			2
E					2						3	2	2

team size, collaboration in care networks is less complex if only one actor supports the care recipient in everyday life." When determining the taxonomy characteristics for a care network, it is important to focus on one dimension at a time. When all characteristics have been determined, a holistic view emerges that can help to determine possible interrelationships and derive implications for action (e.g., the introduction of new technology).

6.3 Types of care networks

The clusters are shaped by different characteristics drawn from 13 dimensions; thus, it is challenging to find simple names for them or compare them. Figure 4 presents an attempt to highlight the shaping features of each cluster in a simplified manner.

Technology was not considered an active actor in any of the surveyed cases; rather, it was considered a passive part of the care infrastructure. Only if technology were to play a role in coordination of tasks (e.g., a matching tool for tasks and actors) or active communication of information to the other actors (e.g., a monitoring system that surveys a person in need of care and alerts other actors in case of an emergency) could it be counted as a (professional) collaborating actor in a network. In some cases, technology may be a crucial part of the network infrastructure, but it is not an active, steering, executing actor in the collaboration.

In the following presentation of the five clusters, the cluster descriptions were enriched with scenarios of typical care networks constructed from the

interview data. Since technology was not an active actor in any of the cases, it does not appear in any scenario.

6.3.1 Cluster A: The conductor – One coordinator managing demand-driven communication

Cluster A is characterized by stability within the network. The network of care is coordinated by one actor, who may also be the person in need of care. The communication channels are clearly regulated and run through the actor who is primarily responsible for the network. The relationships between the actors in this type of network are free of tension, and the tasks of the individual actors are clearly defined and regulated. Therefore, tasks are either separate (i.e., each task is conducted by one actor) or clearly divided (i.e., a group of actors shares the same task). The main actor is responsible for organizational tasks and often much of the day-to-day care. This type of network usually consists of a single actor group. Although the need for communication in the network is relatively high, no clear rules of agreement exist or, if they do, they are not respected by all actors. Communication between the actors is therefore spontaneous and driven by demand. The coordinator or responsible actor contacts other actors when necessary. However, it is clear who can be reached and how.

A possible scenario for this network is as follows. Anna is 85 years old. She is physically fit for her age and can therefore live in her own apartment. She is also mentally fit, and she can organize the support she needs on her own (main coordinator) and does not allow others to help her with organization. However, she is dependent on others for the execution of certain tasks, such as domestic work and driving. Anna has three children and several grandchildren who support her. Her son Tom, his wife, and two adult grandchildren live nearby. Tom provides regular support once a week, and he goes shopping with Anna and manages her finances on demand. Anna's daughter cleans the apartment once a week and does the laundry. If Anna needs anything else, such as a spontaneous visit to a friend, she looks for one of her grandchildren in the yard. Usually, there is someone available to help.

6.3.2 Cluster B: Everything but a team – Clear separation of tasks with unregulated communication, despite a high need for communication

Cluster B is characterized by unregulated communication channels. Each time communication is needed, the actor who needs to contact another must figure out how to do so. Communication regarding certain topics only takes place between certain actors, as there is a clear separation of tasks between the actors. However, three to four actors must always be involved to reach a decision. There is no one actor who has all the information. Given the high level of coordination required in this type of network, unregulated communication can

lead to a high overall time expenditure for coordination, especially because the organization responsibility is not managed by the person who executes the day-to-day care. The organization and execution of certain activities are the responsibility of different actors, which can occasionally lead to tensions. However, all everyday actors live or practice in the same district or area; therefore, regular in-person encounters can calm tensions. Despite challenges, the actors are reliable and support the network in the long term.

A possible scenario for this network is as follows. Berta is 80 years old and was diagnosed with diabetes and Alzheimer's several years ago. Berta lives with her husband in her own home and is supported by a professional care service provider and her family. Berta's daughter Klara has taken over the main organization of Berta's care. Klara lives 50 km away, so she can only sporadically help onsite. She has arranged for the care service provider to come daily to administer insulin and assist Berta with personal hygiene. Berta's husband takes care of the household. Berta's sons Fred and Egon and her adult grandchild Trisha do the driving and the shopping. Klara finds it difficult to coordinate and organize the tasks within the care network. For example, when Klara makes doctor appointments, she must coordinate with her brothers about driving, which takes a considerable amount of time. Daily information about Berta's condition is exchanged between Klara and her father, and there are frequent misunderstandings between them. Moreover, Klara is not easily reached by the other actors in the network because she cannot always pick up the phone at work.

6.3.3 Cluster C: Separate and yet connected – Several coordinators and separate workloads

The care networks in Cluster C consist of at least two actor types. The cluster is characterized by several coordinators who communicate with specific actors regarding specific topics. Thus, the communication in this type of network is described as "separate." No rules govern when to talk about what with whom. Several actors share one or more task fields. The organization and implementation of everyday care are distributed between several actors. The network is stable, and there is a need for coordination among no more than four actors. The communication pathways are unregulated; however, it is clear who can be reached and how.

A possible scenario for this network is as follows. Cora is 82 years old and has a high need for day-to-day care. Her two daughters share the responsibility of looking after Cora. On Mondays, Tuesdays, and Saturdays, Mary is responsible for her mother. On Wednesdays, Thursdays, and Fridays, Nina is responsible. Nina usually makes arrangements with the nursing service and doctors, and Mary usually makes arrangements with the casual helpers. There is always some

overlapping of appointments. Therefore, the two sisters often consult each other to share the information they have exchanged with other actors in the care network or to ask and answer questions. Frequent telephone calls are necessary.

6.3.4 Cluster D: The tidy ones – Coordinated network with clear separation of tasks and communication

In Cluster D, up to four actors provide support for the care recipient in everyday life, and coordination of care is managed by one actor. The relationships between actors are free of tension. All communication is routed through the primary responsible actor, who shares information with the team in a star-shaped manner. A clear separation of tasks exists, whereby the daily organizational tasks and the implementation of daily care are executed by different actors. There are fixed rules regarding how the actors in the network exchange information, and communication channels are clearly regulated.

A possible scenario for this network is as follows. Donald is 76 years old and bedridden. His wife Olga coordinates all necessary care tasks and is always ready to help. Olga is supported in caring for Donald by a care service provider, who is responsible for bodily care, and her son, who is responsible for repair work in the home. A nurse visits daily; thus, most issues can be addressed through in-person conversations. If there is additional need for consultation, Olga can call the care service provider's office 24 hours a day. The son lives two floors above Donald and Olga. He stops by nearly daily; thus, most issues can be discussed in person. In all other cases, Olga can reach her son on his mobile phone.

6.3.5 Cluster E: At the fair – Large network with a high frequency of consultations

Cluster E is characterized by a collaborative mix of professional, informal and semiprofessional actors. The networks in this cluster are rather large, with at least five actors supporting the care recipient in everyday care. There are separate lines of communication between the actors such that certain topics are only communicated among certain groups of actors. Several actors share one or more task areas. The network is rather unstable. Despite a high need for coordination several times a week between usually more than four actors, there are no set rules for communication or the rules are not observed. However, the communication channels are known to the actors.

A possible scenario for this network is as follows. Emil is 70 years old and shows early signs of dementia that coincide with depressive moods. At times, he has no drive and neglects his personal hygiene and household. Emil's need for support varies based on his daily mood. He also needs help related to Parkinson's disease symptoms. Emil receives lunch from a delivery service. A care service provider comes once a day to put on his compression stockings and helps him

shower once a week. The care service provider has a high staff turnover, and different nursing staff have contact with Emil. His son Steward lives 50 km away. He has organized a neighborhood helper to clean and hired the care service. Depending on Emil's mood, he sometimes repeatedly refuses the services. Emil's daughter Larissa is a doctor who has irregular and unpredictable working hours. Her plan is to visit her father twice a week to complete any tasks that arise; however, due to her work, she is not always able to come regularly. A neighbor often takes Emil with her to the city. She is a friend of Larissa's, and they regularly talk about Emil. Larissa and Steward, Emil's son, talk to each other sporadically. Therefore, Larissa often does not know which services have been provided for her father. Emil has no clear overview of the situation and therefore is not a reliable source of information.

6.4 The potential role of collaboration technology in the clusters

In this section, the observed interrelationships between the potential role of collaboration technology and the identified types of homecare networks are presented.

6.4.1 Network particularities

Collaboration technology is intended to create transparency and awareness. As explained in the introduction, homecare actors often lack team awareness and transparency regarding each actor's roles and tasks. Technology that enhances transparency and fosters team feeling may therefore be beneficial for all identified clusters. For the large networks in Cluster E, the use of collaboration technology seems particularly suitable because these networks have the highest complexity in terms of actor diversity. Information and roles can be made visible via notice boards, messengers, and shared calendars, thereby fostering transparency and team spirit.

6.4.2 Task particularities

In many cases, information does not reach all actors, especially in networks characterized by a clear separation of tasks. Considerable organizational effort is required to provide all actors with a complete overview of the situation. The networks in Cluster B are characterized by a clear separation of tasks. A digital notice board would enable all actors to share their observations and considerations and thus ensure a satisfactory flow of information.

If several actors share tasks (as is especially true for the networks in Clusters C and E), clear communication about what needs to be done is mandatory. Additionally, in the Cluster C networks, several actors coordinate tasks that are performed by other actors. In these cases, a shared calendar and task list could be helpful.

Lack of transparency regarding the network actors' tasks and roles can lead to tensions. The networks in Clusters C and E seem to be particularly affected by such tensions. In these cases, collaboration technology that ensures visibility of all actors and their tasks and roles could significantly contribute to reducing tensions, create opportunities to recognize each other's efforts, and provide support in the coordination of tasks. In addition to systems that make the members and their roles visible to everyone in the network, the use of artificial intelligence that matches tasks with available actors (thus supporting task coordination) may also be useful and would incorporate technology as an active collaborator.

6.4.3 Communication particularities

Communication problems were continuously reported in the preliminary studies. Common issues include a lack of communication and sharing of information between informal and professional caregivers, problems with coordinating activities due to time-consuming telephone appointment scheduling and the unknown availability of care actors.

In the networks in Cluster A, all communication goes through the primary responsible person, who passes on information to the team in a star-shaped manner. The communication effort is particularly intense for these coordinators to keep all actors fully informed. In the networks in Clusters C and E, several coordinators communicate with specific actors regarding specific topics; therefore, information only flows to certain actors in the network. The use of collaboration technology (including group messengers and task lists) could help to distribute information directly to all network actors and facilitate coordination tasks. Collaboration technology can be used to replace separated communication with inclusive communication.

Clusters B, C and E have particularly high needs for communication between actors. However, in most cases, there are no set rules for consultations or not all actors stick to the established rules. The networks in Cluster E are especially prone to have unclear communication rules due to the mix of actor types. Collaboration technology that enables actors to share their availability and preferred communication channel could reduce the amount of effort required for communication and introduce binding consultation rules.

To summarize this section, we conclude that collaborative technology has the potential to improve communication and coordination in all the network types presented. However, based on the study findings, collaborative technology would be most beneficial in the networks in Clusters B, C and E.

7 Discussion

7.1 Implications regarding homecare collaboration

7.1.1 Diversity (and complexity) of homecare networks

Several studies in CSCW have addressed the structures and practices of homecare networks to inform the design of ICT to support care coordination. Homecare contexts are often classified or defined by a single feature, such as the health situation of the care recipient or the care setting. For example, studies have examined care networks for dementia patients (Neubert et al., 2020), community-dwelling older adults with physical health impairments (Broese van Goenou et al., 2016), patients with chronic conditions (Langstrup, 2013) and childcare (Gui and Chen, 2019). However, our study findings indicate that collaboration within a care network is not only dependent on the health situation and daily needs of a care recipient but also on the characteristics of the care network itself.

Care coordination is a complex task, and the diversity of and within care networks contributes to the complexity of care collaboration. Increasingly, networks include not only family members but also other informal actors (e.g., friends, neighbors) and semi-professional actors. In some cases, many professional actors are involved in care (e.g., in Scandinavian countries - Bossen et al., 2013; Meagher and Szebehely, 2013), and in some cases, few are involved in care (e.g., Gutierrez and Ochoa, 2017); however, there are almost always several actors involved in care collaboration, as represented in our study sample. Instead of focusing only on a single care constellation type, our study sample was found to represent a broad mix of care network characteristics (e.g., informal; informal and semi-professional; informal and semi-professional and professional).

In practice, the care recipient's needs and the needs of certain caretaker groups are commonly considered. However, other factors, such as the composition of a care network and the opportunities for exchange within it, determine the success of collaboration in a care network (Broese van Groenou et al., 2016). In this study, we enumerated a list of factors that contribute to care network success and organized them into 13 dimensions.

Our developed taxonomy describes several typical structures of organization and communication and their effects and can be used to develop appropriate technical configurations for care networks. The structure of homecare networks is important to consider in selecting and using different available IS. For example, legal framework conditions may be a factor in considering certain systems if professional actors are involved in the network. The distribution of coordinating roles and articulation work are also decisive factors.

It is often assumed that there is a primary caregiver in a care network who is solely responsible for articulation work and network management. However,

in some cases, such a person does not exist or, as in the Cluster C example presented in the previous section, this role is shared by multiple actors who work together to organize the care work. In this case, the relationships between actors in the network are more complex, which may lead to a greater risk of information breakdowns and misunderstandings. Application of the developed taxonomy reveals that articulation work, as described by Bossen et al. (2013), is of varying complexity. Specifically, it is less complex in the networks in clusters A and D and more complex in the networks in clusters B, C and E.

7.1.2 Tensions and dynamics of care work and care coordination

Our analysis reveals differing perceptions regarding what constitutes care and care work. In line with existing literature (Kaziunas et al., 2019), we observed that many significant activities are not identified as care work and thus remain invisible. Our interviewees often declared that they were the primary and sole person responsible for caring for a care recipient, yet during the interviews, it became clear that these declarations were inaccurate. Furthermore, the caregivers we interviewed often did not perceive themselves as part of a network, which can lead to tension and conflict. As in Gutierrez and Ochoa's findings (2017), articulation work was not defined and perceived as a task in our surveyed networks. As a result, communication channels and tasks were unclear and the flow of information was disrupted. The presence of a committed primary caregiver who is responsible for establishing fixed rules regarding how the actors in the network exchange information and regulating the communication channels, as in the networks in Cluster D, can ease tension and conflict in caregiver relationships.

Disparities exist not only between homecare networks but also within them. Actors do not always share common ground. They are divided by financial, spatial, or social inequalities (Schurgin et al., 2021; Franke et al., 2019; Kaziunas et al., 2019), which may lead to diverse role expectations and value for each other. Some actors may disdain the work of others. Our findings indicate that the use of technology could lead to higher task transparency and awareness of other actors in a care network; however, it could also put more pressure on individuals who may feel obliged to perform certain care tasks. We therefore conclude that incorrectly applied technology could visualize, enhance and cement caregiver tensions instead of reducing them.

Further, care actors often make assumptions about what is happening within the network, including who does what and when. Particularly in homecare collaborations, roles are often not "fixed." Rather, the care arrangement is a network of shared responsibility in which actors assume floating roles (Bødker, 2017). Such dynamic "knotworking" (Abou Amsha et al., 2021) of care collaboration is most visible in the instable care networks in Cluster E. Organizing the structures of collaboration in such a network is not a one-time task. Rather, the constant designing of care is work that involves regular rounds of negotiation. Ideally, this

role should be filled by a (publicly funded and established in the healthcare system) caretaker, case manager, community nurse or intelligent technology. This actor could initiate, moderate and accompany the necessary discourse. Neither in the literature nor in the observed cases did case management play a decisive role in organizational work. If case management is to be established as a role within care networks, technology used in the network would need to accommodate this role.

Our taxonomy may be used as a tool to understand care networks and support tension-free and equal negotiation of collaboration arrangements incorporating a "participatory infrastructuring" approach (Kaziunas et al., 2019; Bødker et al., 2017), with and for all actors involved.

7.1.3 Between empowerment and over-burdening: The role of technology and professional support

Information systems that support care coordination are often designed with professional users in mind – they support professional work processes rather than facilitating everyday needs of patients. Kaziunas et al. (2019), among others, have argued that healthcare infrastructures are "leaving many important forms of collaborative care work overlooked." They have highlighted the diversity of "the informal (and often invisible) practices people demand upon to manage their health needs," and pointed out that marginalized groups often remain in the "infrastructural shadows" of the formal healthcare system. Our results support these findings by revealing a diversity of (informal) collaboration structures and practices, and our taxonomy may help to capture the complexities of care coordination.

ICT tools for patients and their informal caregivers are often designed to support self-management and empowerment. However, infrastructural studies have criticized this perspective (e.g., Kaziunas et al., 2019; Gui and Chen, 2019) and the empowerment narrative by arguing that there is no choice to engage or not engage in the healthcare management and that most approaches are limited by systemic challenges and health disparities. Kaziunas et al. (2019) have proposed the concept of "precarious interventions" to understand the emergence of infrastructural ruptures in the setting of systemic health inequities. Some disputes are not easily resolved or repaired but must be routinely negotiated. For the design of care and repair work, the underlying messiness and high risks must be captured (Kaziunas et al., 2019).

The introduction of technology can assume a high level of personal responsibility, which may lead to tensions related to inequalities. If an actor is unwilling or unable to participate in the technology usage, this actor is then cut off from this type of digital information. Collaboration technology may enhance inequalities and thus inhibit further participation in the homecare network (or at least the technical part of the network).

As Abou Amsha et al. (2021) have noted, collaborative practice has been reflected not only in CSCW research but also in healthcare services design (through concepts such as continuity of care, interprofessional collaboration or case and care management). If IS are designed to compensate for a lack of professional support for care management by emphasizing "empowerment" of self-management processes, this design will overburden many informal caregivers. Instead, we think that IS should be seen as a part of integrated healthcare services that provides support for care coordination. Analyzing the Buurtzorg model in the Netherlands, Nandram (2017) has demonstrated that technology-supported collaboration can work "to reduce the complexity and therefore create more time for serving the client in the best possible way." However, the needed changes in the mindset, organizational framework and national health care policies have prevented this model from becoming mainstream (Hegedüs et al., 2022).

7.1.4 Design implications for homecare collaboration technology

Various CSCW studies have examined the current care situation, determined possible technology demands and suggested implications for an ideal design (Procter, 2014). However, this approach oversimplifies the complexity of homecare collaboration and fails to consider that there "is no one-size-fits-all solution" (Gutierrez and Ochoa, 2017) for homecare collaboration. Access to information through collaboration technology "has to be possible and restricted at the same time" (Abou Amsha et al., 2021), because it is not possible to know in advance who will need access to what type or level of information and at what time. Rather, we can conclude from the cluster analysis findings that network requirements and design recommendations sometimes play a lesser or greater role. Corresponding configuration options are necessary for the different network types (e.g., more dynamic vs. more stable, professionally controlled vs. informally controlled constellations).

Particularly in the unstable networks in Cluster E, the focus should be on fostering "knotworking," which implies that interpersonal relations and introspection work should be supported through collaboration technology (Schurgin et al., 2021). Instead of focusing on clinical patient network aspects and productivity tools, solutions must also support caregivers to acclimate to life as a caregiver, enable trust and foster a sense of connectedness among caregivers and the care recipient (Schurgin et al., 2021). We observed in many cases that informal caregivers do not see themselves as caregivers, nor are they perceived as such by others, and they are therefore not valued accordingly. Technology should support appreciation for informal caregivers and clarify one's own understanding of one's caregiving role.

There is a particularly strong need to support dynamic role identification. Technology must be adaptable to the dynamics of care networks by making the different roles in care networks visible and supporting role changes. In line with

Procter et al. (2014), we argue that technology must also be adaptable or configurable to the different levels of knowledge of care actors so that everyone can use the technology and no tensions are created through social inequalities or inequities. Further, common knowledge and intelligence in care networks should be mobilized so that everyone is empowered to use the technology (Procter et al., 2014).

The age of actors may not significantly affect their general interest in using technology to enhance care collaboration; however, age plays a role in choosing suitable collaboration technology in the sense that the design and usability of software must be adapted to age-specific limitations. In English-speaking countries, there are versions of applications that are adapted to the needs of the respective user types. For example, Goubran (2017) describes an application that runs on a special tablet in the home of an older person in need of care, whereas the same application is available to a younger caregiver as a smartphone app.

As computing systems advance, an increasing amount of artificial intelligence (AI)-driven assistance will be available (Schurgin et al., 2021). We agree with Schurgin et al. (2021) that it will be vital for informal caregivers to be continuously involved in the design of algorithmic decision-making as technology advances. The challenge of such advances will be to respect human expertise, the dynamic complexity, fairness for all involved and privacy issues.

7.1.5 Implementation of collaboration technology into homecare networks

Limiting the discussion purely to the design and advantages of using technology would neglect the multifaceted nature of implementing technology. As mentioned in the introduction, implementing technology is a "complex intervention" that must be considered according to seven domains (Greenhalgh et al., 2017). New collaboration technologies often compete with standard tools and pre-established work processes. For example, some of the networks in this study already use modern ICT for care planning. The technologies used tend to serve a singular function. The shareable calendar Google Calendar was used by coordinators in some care networks for organizational tasks and optional sharing of information with family members. The telephone was dominant in all networks. The messenger service WhatsApp was used in the informal and semi-professional sector without consideration of data protection. Danholt and Langstrup (2012) have stated that "[designers] and policy-makers often operate with the metaphor of a gap that needs to be bridged by information technology." This study supports the observation that even if no care-specific IT infrastructure is used at a given moment, the terrain between the care actors "is certainly not empty" (Danholt and Langstrup, 2012). Although we observed "bricolaged" (Procter et al., 2014) networks that were cobbled-together in the process of care, their collaboration processes were generally established and accepted by everyone in the network. The introduction of (more) technology could possibly improve these processes

in terms of transparency, but introducing technology involves additional work. An acceptance of the current care situation and a negative attitude toward change among some of the care actors is expected, and such attitudes have been reported in the literature (Kemper-Koebrugge et al., 2019; Renyi et al., 2019).

Additionally, even if technology might be successfully used to create transparency regarding tasks and activities performed and thus reduce tensions, increased transparency in the network could also increase tensions if actors reproach others for unequal distribution of work. Technology cannot evaluate the importance of certain support actions, because these actions often have subjective value. For example, caring for someone through an occasional phone call might be of greater value to the person in need of care than practical support in the household. To successfully implement collaboration technology, all the above aspects must be considered.

7.2 Applicability of the taxonomy

The taxonomy developed in this study is one of our main contributions to the body of knowledge. In this section, we will summarize the added value that can be achieved through its application.

7.2.1 Tool to foster practical understanding of collaboration technology benefits

Going beyond other studies that have classified care collaboration (Neubert et al., 2020; Broese van Groenou et al., 2016), the taxonomy developed in this study explicitly includes technology as a potential collaborator. Whereas Broese van Groenou et al. (2016) clarified the linkage between formal and informal caregivers, this taxonomy highlights the role of technology in this linkage. The taxonomy contributes to a nuanced understanding of technology that distinguishes between its roles as a passive part of the care infrastructure or an active collaborator in the care network. Additionally, the taxonomy clarifies the case-specific benefits of collaboration technology.

This knowledge could be particularly useful for collaboration technology providers to illustrate the advantages of their technology over standard ICT and develop sustainable business concepts. However, other decisive factors for successful technology adoption, such as knowledge of the goals of technology use, must be considered (Breebaart and Broese van Goenou, 2018).

7.2.2 Tool for scientific sample optimization

The taxonomy may prove useful for future studies that focus on collaboration technology for homecare networks in several ways. The taxonomy could be applied in the sampling phase of a study to identify the most appropriate networks from which to draw a sample. Although the added value of care collaboration technology has not yet been definitively demonstrated (Willard et al., 2019), it may be possible to demonstrate it for specific clusters. The taxonomy could

also be applied retrospectively to determine what was investigated in a study and clarify the obtained results.

7.2.3 Tool to foster discussion and consensus building within care networks

Infrastructures are often black boxes that remain translucent in supporting tasks and only become visible when they break down (Star and Ruhleder, 1996). The developed taxonomy can enable "introspection work" (Schurgin, 2021), which in turn can enable repair work before a network breaks down.

Broese van Groenou et al. (2016) recommend that homecare organizations should analyze informal care networks. We believe that lay caregivers should also be empowered to do so and to make decisions accordingly. To support this purpose, the taxonomy has been transformed into a practical guide. A German and an English version of this guide can be found in the supplementary materials (Appendices 1 and 2) or as an online survey (Renyi et al., 2021a, 2021b). Through the application of the taxonomy, actors in homecare networks can identify their type of collaboration and collaboration problems within their network. These problems can then be discussed within the care network, and joint decisions for improving collaboration can be made. For example, such decisions could lead to the introduction of collaboration technology or reduction of the use of technology. To accompany the negotiation process and to account for ethical issues resulting from the analysis, we recommend a fostering of case and care management for professional guidance in all countries' health systems. Professionals could counsel actors in homecare networks and help to uncover possible inequities related to technology usage.

It is important to recognize that the developed taxonomy can only provide an assessment of the current situation. As conditions and supporting infrastructure (human and non-human; Danholt and Langstrup, 2012) change over time, iterative reevaluations using the taxonomy are recommended. Through continuous reflection, mutual understanding can be fostered (e.g., care consists of not only bodily care but also social issues, companionship, etc.), and the dynamic process of "knotworking" (Abou Amsha et al., 2021) can be negotiated through discussion and consensus building.

7.3 Methodological limitations of the development of the taxonomy

The development of the presented taxonomy had several limitations. The sample was biased toward the German healthcare sector, which fundamentally informed the characteristics of the investigated homecare networks. Additionally, the sample of 21 care networks acquired in Stage 2 was a convenience sample. Therefore, the taxonomy may be limited in its completeness (Nickerson et al., 2013), as it is unclear whether all German homecare networks would fit into the proposed classification. The proposed taxonomy is comprehensive of the investigated

cases; however, a larger sample would likely produce a slightly different taxonomy. Further empirical-to-conceptual iterations may produce more, reworked, or fewer dimensions. Additionally, a larger sample would help determine the appropriateness of the selection of characteristics for each dimension and their separation criteria. Further research is needed to determine whether the dimensions and their specific characteristics are unambiguously understandable or whether the descriptions are open to interpretation. The latter could lead to differing classifications of networks.

Two of the thirteen dimensions (task division and task coordination) were not classified as "highly complex" in any of the examined networks, and another two dimensions (team size and communication pathways) were not classified as "less complex" in any of the examined networks. The poles of the dimensions are not fully exploited in the examined networks; thus, one could conclude that the true diversity of homecare networks is not represented in the sample. However, it is also possible that the chosen characteristics were too narrow or broad, and different or fewer characteristics may be required for some dimensions. Further research is needed to clarify this point.

Another limitation of the study is the proximity of the individual dimensions to one another. This limitation was particularly evident in the correlations between the dimensions, which revealed several dependencies among them. For example, task coordination was strongly correlated with task division and task type. A larger study is necessary to clarify the extent of these correlations and any necessary changes to the taxonomy. A different clustering approach might have produced slightly different results.

Finally, we must consider the possibility that a weakness of the taxonomy is a "lack of changeability" (Bailey, 1994). Models are generally static but must be adaptable to future changes in the care system. Although the existing classification is currently valid, it will likely require adjustments to remain applicable in the future.

This taxonomy is therefore a starting point for further consideration and future study. For example, future studies could investigate the number of characteristics in each dimension. It is conceivable that a further division or reduction of the number of characteristics for individual dimensions would be useful. Inclusion of additional cases could also lead to the formation of new clusters.

7.4 Further limitations, outlook and open research questions

The discussion section has identified open research questions regarding homecare networks and the presented taxonomy. Questions regarding the use of technology and its impact on network collaboration must also be considered. Although individuals in 21 networks agreed to participate in interviews for this study, most individuals were unwilling to introduce (further) collaboration technology into their network. This study was therefore unable to investigate questions

concerning the influence of technological interventions on collaboration in homecare networks on a large scale. Open research questions for future studies include the following: What is the impact on a network's composition when technology is introduced or changed? How do the characteristics of the dimensions change for the observed network? What other changes are observed when technology is introduced or changed? If the introduction of technology could be observed on a large scale, the potential of technology usage for the different clusters could be further determined.

We provide the taxonomy as an online self-assessment tool (Renyi et al., 2021a, 2021b) to enable its large-scale use, scientific evaluation, and maintenance through a citizen science approach and to enable data generation through the taxonomy. This taxonomy can then be used by researchers and homecare network actors to receive feedback on any network of interest, monitor network changes over time, or compare networks with one another.

8 Conclusion

This study substantiates the claim that there is "no one-size-fits-all solution" (Gutierrez and Ochoa, 2017) to support care network collaboration. The research approach was motivated by the possibility of introducing collaboration technology into certain care networks. Therefore, a taxonomy for homecare collaboration was developed. The following cluster analysis resulted in five derived types of care networks. The cluster analysis highlighted that technology implementation may not be equally beneficial in every case. Rather than creating and implementing more "advanced" technologies, we agree with Procter et al.' (2014) assertion that the success of aging in place is dependent on "effortful alignments" of the organizational and social configurations of support and collaboration. The role that technology could and should play in these configurations is important to consider. The implementation of new technology is work; therefore, this additional work should only be conducted if real benefits (e.g., reduction of workload and/or network tension) are likely to be achieved through use of technology. Using the developed taxonomy, the "roles and caregiving activities can be made explicit" (Gutierrez and Ochoa, 2017) without use of technology, which may be beneficial for all care networks.

An initial analysis of the value proposition of collaboration technology for the identified clusters revealed that three of the clusters may particularly benefit from using collaboration technology, based on their collaboration complexity. This study is the first to shed light on the interrelationships between network types and the value proposition of certain collaboration technology components. However, it is important to note that the taxonomy is not designed to derive statements regarding the actual adoption of technology.

In its current form, the taxonomy may prove useful in several scenarios. For example, it could help to foster understanding and discussion within homecare networks through its application on a continuous basis. The taxonomy could also be used to identify appropriate networks for future study samples to examine the added value of collaboration technology components for homecare networks.

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Declaration

Conflicts of interest None

Consent to participate All participants of the study were informed prior to the interviews about the aim and procedure of the study, as well as their rights to withdraw from the study without personal consequences. All participants gave their written consent to participate in the study.

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