Assessment

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Collaboration applications for mixed home care — A systematic review of evaluations and outcomes

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Objectives. Mixed home care, in which informal and professional actors work closely together, contributes significantly to ensuring home care up to old age. In this context, collaboration applications can considerably enhance the interactions among caregivers. However, although much research is conducted on need and requirement analyses of such applications, little is known about their introduction and use in care models. The purpose of this contribution is to identify studies that evaluate collaboration applications for mixed home care and compare their outcomes.

Methods. To identify literature on mixed home care collaboration applications (mHCA) and their evaluation, a systematic literature review was conducted in five bibliographic databases covering the years 2008 through 2019. The results were supplemented by a search in the meta-database Google Scholar. The evaluation approaches of the studies were analyzed and results compared by using the NASSS framework. Finally, a context concretized model was derived which summarizes interrelations.

Results. Twelve qualitative studies evaluating eleven applications could be identified. They report on increased competency in self-management, psychological relatedness, involvement, and understanding. However, most studies conclude that large scale platform tests are still needed to prove significant changes in care processes, communication, or organization.

Conclusion. Among other things, their implementation is rather difficult due to the specifics of the target group. To enable a more targeted and successful implementation, it might be helpful to classify care networks beforehand and assess their communication behavior and needs. To prove the added value of mHCAs standardized assessment tools should be used.

Collaboration in Mixed Home Care

Due to demographic change, many countries face the challenge of ensuring adequate care for elderly people. In Germany, more than 3 million people are currently in need of nursing care, 81 percent of whom are aged 65 years or older (1). Although 27 percent of the care-dependent elderly people live in nursing homes, more than two thirds are cared for at home, where care is accomplished by a variety of only weakly connected caregivers (2) such as relatives, friends, neighbors as well as healthcare and nursing services (3). To ensure the best possible care for the person in need, it is essential to coordinate all involved actors. The multifaceted and complex task of organizing and coordinating the various supporting caregivers is usually performed by a caring relative (4) for whom daily care is usually already an enormous burden. Therefore, technological support can be a great benefit particularly for informal caregivers and can thus strengthen care networks (4).

Computer-Supported Collaborative Care (CSCC)

The research field of CSCC is particularly concerned with the question of how technology can support entire care networks for the elderly living at home. In contrast to the research field of computer-supported collaborative work (CSCW), the focus of CSCC is more on a person than on a shared objective (5), and aspects such as emotions, trust, privacy, and so on are considered more important (5) than increases of efficiency and effectiveness of work processes. Unlike in large health facilities, the use of technology is less common in mixed home and community care, although several studies point to its importance and potential for the networking of caregivers (6–13).

In home care, the telephone is still the predominant medium of communication, supplemented by numerous handwritten memos at the patient's home (14). Applications that help to organize the daily care work and coordinate the caregivers involved can therefore contribute significantly to improving mixed home care situations (15).

The recognition of this potential has led to the development of a variety of care collaboration software tools for mixed home care (16), including research prototypes such as CareBetter (17), Cuidador Acvida (18), and Zirkel (14) as well as commercial applications such as Carezone (19), Jointly (20), and CaringBridge (21). In the United States of America (USA), Carezone claims to have more than 5 million application installations. Despite strong efforts to create the necessary software that is adapted to the target group (22–26), the adoption of such technologies in Europe is still relatively low. The most widespread European app, Jointly, only has 1,000+ installations from the Android Play Store (access date: 28 May 2019) (27).

The introduction of technological support systems into mixed home care constitutes a complex challenge, as varying expectations of different actors (patients, informal and professional caregivers, and society) have to be matched (4;28). The complexity of the introduction of technological applications in the healthcare sector can be evaluated by means of a systematic framework. In 2017, Greenhalgh et al. (29) presented a new framework for theorizing and evaluating Non-adoption, Abandonment and challenges to the Scale-up, Spread and Sustainability of health and care technologies (NASSS), based upon their own studies as well as other theoretical frameworks. The NASSS framework (29–31) includes seven domains: "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" (29). Therefore, the framework takes into account not only the specifics of the respective networks, but also the aspects associated with the introduction of the new technology and the consequences that may lead to changes during implementation.

It is also assumed that the more complex the individual domains are, the less likely it is that the technology will achieve sustainable acceptance across the system. Thus, the framework was designed to capture the complexity and provide appropriate handling support (29–31).

Motivation, Aims, and Research Questions

In a participatory design process, in which nurses, neighborhood helpers and caring relatives had been involved, the authors of this paper developed a collaboration prototype for mixed home care (14). However, several barriers hampered the evaluation beyond screen-based prototype testing. Despite a broad recruiting strategy, only some caregivers could be encouraged to evaluate the prototype. But as the commitment of entire care networks was lacking, field tests failed several times, as did the adoption and scale-up. Some field tests had to be aborted prematurely because the health status of patients deteriorated or patients deceased.

These difficulties motivated the authors to closer examine the current state of mixed home care collaboration application (mHCA) evaluation. Methodological aspects of studies were investigated with regard to evaluation instruments, recruiting strategies, and objectives. Further analysis of the identified interventions regarding non-adoption, abandonment, and other challenges was conducted using the NASSS framework.

Our primary research question thus is: How are mHCA evaluated in the literature and how can previous experience be assessed using the NASSS framework? The discussion section of this paper summarizes the results as concretized NASSS model for mHCA for elderly mixed home care.

Methods

In spring and summer 2019, a systematic literature review was conducted using five bibliographic databases (SpringerLink, IEEE Explore, PubMed, Compendex, and ScienceDirect), based on the PRISMA guidelines (32), to identify literature published about mHCA and their evaluation. Although various study results may also be applicable to other home care contexts, the inclusion criteria for studies to be included in this contribution were defined as follows. The studies had to focus on collaboration in home care networks for elderly people, must be written in English and published between 2008 and 2019.

A broad search strategy was employed including the words "(elderly/long-term/home) care," "collaboration/coordination/organization," and "application/intervention." Additionally, a market research revealed nineteen applications available in mobile application stores and on Web sites. Their evaluations were searched using the Google Scholar search engine. The complete search strategy is described in the Supplementary Material.

For study selection, the first author screened the literature databases and applied the inclusion criteria to all titles and abstracts retrieved from the searches, and then added relevant articles for deeper analysis. Independently of each other, the first three authors read all full-text articles and excluded those that did not meet the inclusion criteria. Thereby, the authors came to identical results. The study selection process is presented in a PRISMA flow chart (32) in Figure 1. The appraisal tool "CASP Qualitative Checklist," (33) by the "Critical Appraisal Skills Programme," was used to validate the quality of the selected papers. The checklist was not designed as a scoring system, but as a guide for systematical considerations on the quality of studies. The first two questions (clear formulation of the research aims and appropriateness of methodology) are screening questions to determine whether to proceed with the analysis. All included studies passed this test.

Data extracted from the papers included source, date of publication, title, authors, name of application, country of evaluation, study design, description of application, and summarized results.

Results

The systematic search identified 2,750 papers whose titles and abstracts strongly relate to healthcare collaboration. Additionally, 3,874 papers were identified through the search engine Google Scholar. Seven other studies were identified through snowball search. A total of 6,581 papers were excluded because they did not meet the inclusion criteria. After duplicate removal ($n = 1$), the abstracts of forty-nine papers indicated a possibility of reporting on mHCA, the assessment of which resulted in twelve relevant studies which again evaluated eleven different applications. If an application was mentioned in several studies, only the original evaluation report was included. As Panagopoulos et al. (34;35) evaluated, redesigned, and re-evaluated their application, both evaluation studies were included in the analysis. See Table 1 for an overview of included studies.

Study Designs

All studies emphasize the importance of involving future users in the development process. To create target group specific applications, interviews, workshops, and usability tests were conducted. However, in terms of sample size, duration and type, the
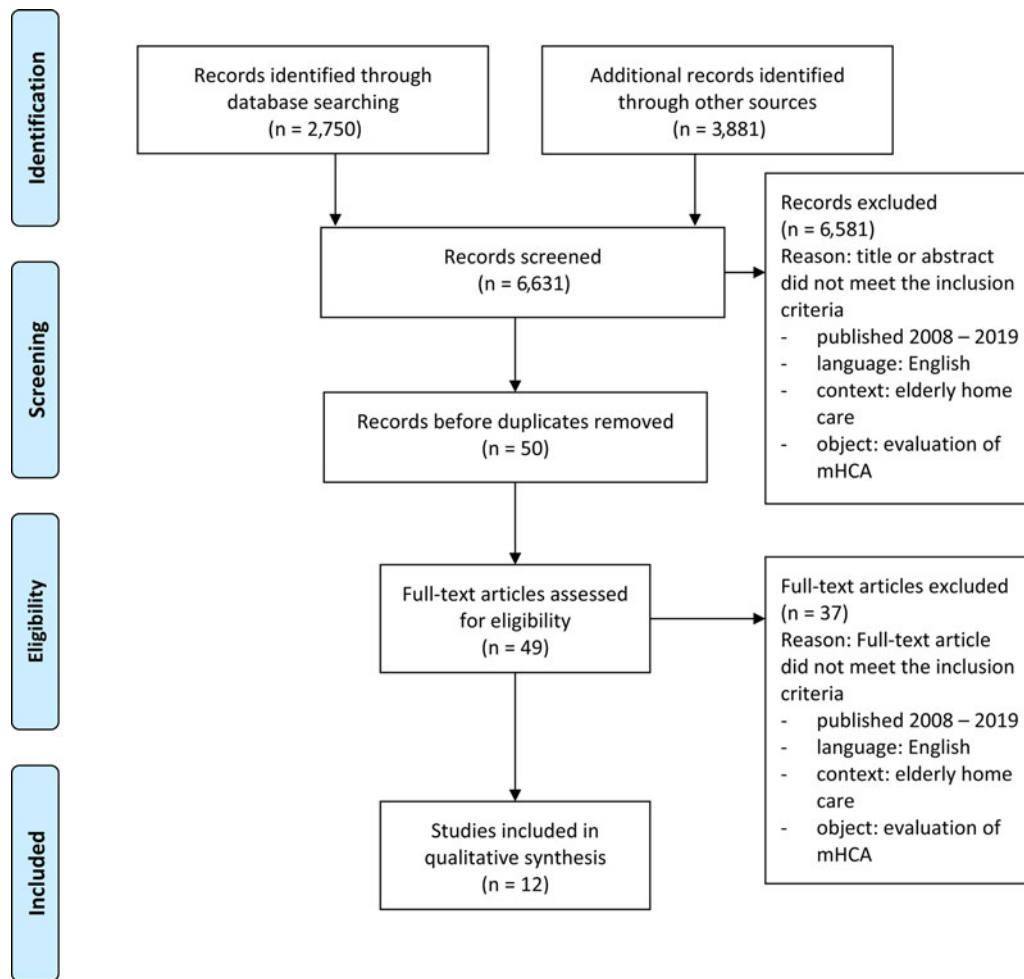
Figure 1. PRISMA flow-chart of literature selection according to Moher et al. (32).

evaluations vary widely. Four studies (18;34;35;37) used 1-day usability workshops, whereas another study (41) observed the usage of an application for more than 6 months. All applications were tested without randomized control groups or pre-post comparisons.

Objectives
Most of the studies included in this analysis investigated the usability of the application technology. For this purpose, three studies used the System Usability Scale (SUS) (34;35;43) and one the Post-Study System Usability Questionnaire (PSSUQ) (39). In an attempt to evaluate additional changes triggered by the introduction of the technology, Martinez et al. (43) investigated caregiver self-efficacy (using a revised scale for caregiving self-efficacy), burden of care (using a short version of Zarit Burden Interview — ZBI) and family structures (using the General Functioning subscale of the McMaster Family Assessment Device — FAD).

Recruiting Strategy
According to the studies, the recruiting was carried out by the project partners or professional nursing staff (39;41;42), word-of-mouth advertising, advertising flyers, and social media posts. Due to the stigmatization of the term "elderly," one study reported

that recruiting older participants was rather difficult, partly because the persons saw no direct benefit for themselves (36).

In general, anyone with a connection to elderly care could take part in the tests. Only one study (40) reported a standardized assessment during the recruiting phase to evaluate participants for study eligibility. One study (39) aimed at a broad heterogeneity, whereas another (42) preferred a homogeneous sample. Overall, however, the selection of participants was convenient.

Nature of Intervention
Condition
The essential inclusion criterion for all studies was the focus on home care for elderly people. The respective characteristics of the care situation can vary significantly depending on the health status (physical and mental state) and the life situation of the respective patient, which greatly influences the care network, the potential adopters of the new technology as well as the applicable technology. Therefore, four studies narrowed the focus to specific conditions (patients with dementia (39;40;43); patients with multiple chronic conditions (37)).

Technology
All evaluated technologies support some form of communication. However, the complexity of the systems varied considerably and

Table 1. Identified applications for care collaboration

Author, date	Name of application/ project	Tested countries	Case numbers	Test period	Type of test	Assessment tools
Riche and Mackay (36)	markerClock	France	1 peer-couple	4 weeks	Field test	–
Bossen et al. (23)	CareCoor	Denmark	5 care networks	6 weeks	Field test	–
Panagopoulos et al. (34) Panagopoulos et al. (35)	BioAssist (HeartAround)	Greece	24 participants	1 day	Lab tests	+
Alkhushayni (37)	CaregiverPal	USA	9 participants	1 day	Lab test	+
Patrick (38)	CareZone	USA	10 participants	2 weeks	Field test	–
Boessen et al. (39)	Cubes™	Netherlands	4 care networks	10 weeks	Field test	+
Goubran (40)	Claris Companion	Canada	6 care networks	6 weeks	Field test	+
Breebaart and van Groenou (41)	dfDNC	Netherlands	7 care networks	6 months	Field test	–
Drugbert et al. (42)	AidAdom	France	3 care networks	4 weeks	Field test	–
Garcia and de Lara (18)	MobiCare	Brazil	7 participants	1 day	Lab test	+
Martinez et al. (43)	Zalio™	Canada	2 care networks	6 weeks	Field test	+

ranged from simple communication (36) to complex health documentation features (34;35). In general, the evaluated applications support collaboration through shared calendars and messages.

Seven studies examined research prototypes. Given that prototypes are inherently immature and generally more prone to unexpected disturbances, the authors reported difficulties, such as instability, uneven performance and low interoperability. Irrespective of the prototype status of the application, it is essential that all components are reliable (23).

The study comparison showed varying requirements for interoperability, data protection, and stability. None of the systems allowing the exchange of medical information achieved sufficient interoperability with pre-established healthcare and documentation systems, which led to extra work for nurses and, consequently, a reduced usage of the tested systems. On the other hand, when less health-specific aspects were included, the benefits of the mHCAs decreased and they did not stand out from standard communication applications. Privacy concerns are often secondary to the user experience for informal caregivers, which conflicts with the necessity of professional stakeholders who have to adhere to privacy regulations.

Nine studies discussed the ways in which knowledge about system use can be communicated to the users. Although some studies argue that the technology design itself must be simple and easy to use (34;35); professional caregivers often prefer formal training to ensure effective work processes (23).

Value Proposition

The value propositions of commercial service providers were not addressed in the examined studies. Seven of the eleven applications were prototypes and therefore did not present or discuss business models. In the studies, the focus was more on the evaluation of the technology rather than on its potential benefit. The studies were conducted to gain knowledge about value propositions to use for future scaling (42), among other purposes. Only one study, Martinez et al. (43), attempted to validate specific value propositions (including perceived self-efficacy and caregiver burden) using standardized assessment tools.

Little information was reported about participants' motivation to take part in the studies. Riche and Mackay (36) stated that their participants attended out of "curiosity about the sociological aspects of communication technology." In general, the participants exhibited a cautious attitude regarding their expectations of the application prior to the test (40). Some users recognized benefits during the tests, whereas others did not name benefits even after the test ended (39).

In summary, the studies found that participants were able to organize themselves more easily and empathize better with the care situation overall ("peace of mind") when using assistive technology. However, despite many such positive reports, all studies concluded that the impact of technology use on care arrangements remains unclear, making it difficult to argue for the use of technology. Eight studies concluded that large-scale platform testing is still needed to demonstrate the usefulness and perceived value of application interventions.

Furthermore, other digital organizing tools, including calendars (42) or WhatsApp (41), were already in use for care collaboration. The various ways to share information (e.g., test applications, the professional agencies' intranet tools as well as the medical reports at the patients' homes (41)) reduced the added value of the mHCA and confused the test users.

Adopter System

All the applications addressed were designed to support collaboration in mixed home care. In nine of the eleven applications also the care recipient was explicitly encouraged to use the system and participate. In fact, three of these applications required the patients to play an active role in the use of technology (18;34;35;40). With the exception of one application with a tandem structure (36), all the others allowed for a flexible number of caregivers. However, only six of twelve studies included all targeted adopter groups.

Generally, the studies faced several limiting factors (e.g., deceased patients (23) and low technical competence of adopters (18)). The heterogeneity of caregivers led to diverging requirements (23).

Health/Care Organization(s)

Furthermore, the studies reported several difficulties, which can be traced back to institutional organization structures. The

organizations have only half-heartedly participated in the studies. Not all necessary actors were informed and trained (23), no official equipment was purchased for the test (41), and the nurses used the technology in their free time without being paid for this work (39). Therefore, although the organizations were basically interested in participating and testing, these examples make the willingness to introduce such a technology appear doubtful.

There are many different providers for the home care sector (such as pharmacies, physiotherapists, doctors, medical supply stores, and mobile foot care). However, there is a lack of professional case managers who would coordinate these services in a meaningful way. This is usually done by the caring relatives, as the individual professional actors do not take over such coordinating tasks as they are not paid for them. Due to this lack of professional coordination, problems related to "limited resources for articulation work and basic information sharing requirements" (42) arise.

Wider System

As can be seen from Table 1, the studies originate from Europe (seven studies from France, Denmark, the Netherlands, and Greece) and North and South America (five studies from the USA, Canada, and Brazil). Although demographic change also affects developing countries, no studies from these countries were identified.

Privacy is a major topic in all studies, although it relates more to ethical than legal aspects. This could be explained by the fact that mHCAs "have fewer privacy problems than eHealth and care records" (41). There is a conflict between the need to preserve "medical privacy" and the need to present information in a way that allows to derive practical tasks (42).

Of all included studies, only Drugbert et al. (42) discuss aspects of interoperability between information infrastructure, sustainability, and governance. They suggested that interoperability is not only linked to "technical interoperability and synchronization issues but also requires to engage work on professional and local categorization schemes" (42). Collaboration platforms involve several autonomous but not hierarchically bound organizations, which renders governance discussions necessary.

Embedding and Adaptation over Time

Five studies (34;35;38;40;43) evaluated four market applications. The main focus of these evaluations was on usability aspects in lab studies. Although the evaluations focus on adapting the technology to meet individual needs over time, effects of embedding technology in care routines and adoption of care networks are not investigated.

Discussion

The aim of this systematic review is to identify and compare evaluations of mHCAs and to determine possible implications of these evaluations regarding the practical use of mHCAs. The NASSS framework proved to be a useful tool to structure the results, reveal specific problems, and clarify the complex interrelationships of all domains.

Analyzing the Complexity of mHCA Implementation

Table 2 summarizes the observed particularities that contribute to the complexity of mHCA implementations in a concretization of the NASSS framework. This should help researchers to better understand the complexity of future mHCA implementations and facilitate the evaluation of individual characteristics of the different home care scenarios. The table has three columns. The first column contains the original NASSS domain, the second the derived concretization for the mHCA use case, and the third the factors that contribute to the complexity of the implementation. Respective references are indicated for the factors originating from examined studies, the other factors represent the authors' own experiences. The table reads as follows: the first domain "condition" is concretized to "home-dwelling elderly." The nature of the condition is frailty. The implementation of mHCA is complex if there is an age-related decline in the elderly's condition. Cognitive health issues as well as motor, visual, or other functional impairments can constitute comorbidities of the home-dwelling elderly. For example, high functional impairments can make mHCA implementations complex, when these hinder the elderly to use standard technology. The spatial closeness of caregivers is a mentioned socio-cultural condition. Missing closeness may increase the necessity for using mHCA. However, a lack of people who can provide personal support complicates the implementation of mHCA. Further factors such as missing infrastructure are also conceivable but were not investigated in the studies. Primarily, mHCA are meant to make better use of existing resources. In regions where there is a lack of family doctors, these network positions remain unfilled and can – of course –, not be compensated by the system. Which technologies (domain 2: mHCA) are conceivable for a technology implementation and which value propositions (domain 3) can be foreseen is, however, strongly influenced by the "adopter system" (domain 4) — the "care network." Depending on the "condition" of the patients, the composition of care networks change. The composition as well as the number of caregivers further leads to varying degrees of complexity. A special group is represented by the "health/care organizations" (domain 5).

The specification of the domain "value proposition" proved to be difficult, because aspects such as peace of mind (23;36), shared responsibility and awareness (36;39;41;42), and community connectedness (36;37;39;40;42;43) are desired but not necessarily achievable, or concretely measurable outcomes. Complexity in this domain may rise when the actors perceive the benefits very differently.

The lack of prerequisites makes the domain "wider system" complex. If there were community-based care models and reimbursement for care coordination tasks, the complexity of introducing mHCA would be significantly lower.

Finally, the degree of implementation affects the complexity of the mHCA implementation. Although answering usability questions in lab studies can be relatively simple, questions about actual care networks may be considerably more complex. Unanswered questions, for example, about interprofessional and interorganizational incentives for networking can only be answered in real-life situations. Due to the limited scope of the field studies, it can be assumed that most of the contributions to complexity in domains 6 and 7 are still not evident and unclear.

Limitations

Similar to any scientific work, also this contribution has some limitations. For one thing, the literature review only found twelve studies that met the inclusion criteria, which may be due to the fact that only studies in English were included. As national

Table 2. Domains and factors contributing to complexity of mHCA implementation

Domain		
Original NASSS	Typical concretization in the context of mHCA	Factors contributing to complexity
Domain 1: Condition	Home-dwelling elderly	mHCA implementation is complex if there is a/are…
(1A) Nature of condition or illness	Frailty	• Age-related decline (18;23;43;34;35;37–42)
(1B) Comorbidities, sociocultural influences	Comorbidities (cognitive health; motor, visual, other functional impairments)	• Poor degree of cognitive health (39;40;43) • High degree of motor, visual, or other functional impairments (23;37;38)
	Sociocultural influences (e.g., living condition)	• Missing spatial closeness to caregivers (35;36;39–41;43) To be determined in later studies, e.g., • Missing infrastructure, e.g., no access to the internet, public transportation, medical specialists
Domain 2: Technology	mHCA	mHCA implementation is complex if there is a …
(2A) Material features	Hardware	• Obtrusive, immobile design (23;36;40) • Poor reliability (23)
	Software features	• Missing inclusive and intuitive design (18;23;43;34–40;42) • Missing adaptability/level of individualization by each stakeholder (34–36;39) • Missing interoperability (23;34;35;39)
(2B) Type of data generated		• Health-specific scope (36;41;42)
(2C) Knowledge needed to use		• Poor learnability (37;38)
(2D) Technology supply model		• Missing or poor training (23;37;38;43) • Missing or poor self-study material (34;35;38;40) • Missing or poor technological support (34;35;38;41;43)
Domain 3: Value proposition		mHCA implementation is complex if there is a …

(3A) Supply side value (to developer)		Mismatch between supply side value and demand-side value, e.g.,
		• researchers:
		  ○ knowledge gain (18;23;42;43;34–41) vs. privacy
		  ○ advance communication (34–36;39) vs. low technology literacy
		  ○ reduce loneliness of care recipients (36) vs. self-determination
		• Commercial service: no business cases proposed in the presented papers
		• Care service provider: simplify work (23;39) (e.g., reduction of personal contact) vs. relationship work

(3B) Demand-side value (to patient)	Demand side value (to care network)	Mismatch between care actor's perceived value proposition (38), e.g., • Community connectedness (36;37;39;40;43) vs. professional actor frontier between professional and private live (42) • Desire to share responsibility and awareness (36;39;41;42) vs. privacy
Domain 4: Adopter system	Care network	mHCA implementation is complex if there is a/are …
(4A) Staff (role, identity)	Participation of professionals	• High number of professional care actors (18;23;43;34;35;37–42) • Different types of professions (23;42) • Low affinity for technology (18;42)
(4B) Patient (simple vs. complex input)	Elderly	• Poor cognitive ability to use mHCA (39;40;43) • Low affinity to use technology (18;42) • Poor physical ability to use mHCA (23;34;35;37;40)
(4C) Caregivers (available, nature of input)	Participation of volunteers (e.g., neighborhood helpers)	• High number of volunteers (18;23;43;34;35;37–42) • Many different fields of application (23) • Low affinity for technology (18;42)
	Family caregivers	• Missing caretaker for organizational issues close by (18;23;42;43;34–41) • High number of long-distance caregivers (18) • Many different fields of application (23) • Low affinity for technology (18;42)
Domain 5: Health/care organization(s)		mHCA implementation is complex if there is a/are …
(5A) Capacity to innovate (leadership, etc.)		• Poor knowledge about possibility to use technology (23) • Restricted usage times, e.g., technology usage only within office hours (39) • Unclear responsibilities (42) • Missing (timely and personal) resources (42)

(Continued)

Table 2. (*Continued.*)

Domain		
Original NASSS	Typical concretization in the context of mHCA	Factors contributing to complexity
(5B) Readiness for this technology/change		• Missing supply of necessary hardware to use technology (39;41) • Other technologies (e.g., intraorganizational documentation system) already in use, reducing the value proposition of new (interorganizational-collaboration) technology (39;41)
(5C) Nature of adoption/funding decision		• Missing funding and sponsorship (38)
(5D) Extent of change needed to routines		• Well-structured established organization system (easy routines) (40)
(5E) Work needed to implement change		To be determined in later studies
Domain 6: Wider system		mHCA implementation is complex if there is a/are …
(6A) Political/policy		• Missing implementation of community-based care models (23;39;42) • Missing reimbursement for care/case management (42) • Missing public funding for technology implementation (42)
(6B) Regulatory/legal		To be determined in later studies, e.g., • Tough rules for data privacy
(6C) Professional		• Missing commitment of professional stakeholders (42;43)
(6D) Sociocultural		• Missing anchoring and acceptance in society (38;43)
Domain 7: Embedding and adaptation over time		The complexity of mHCA implementation regarding this domain mostly has to be determined in later studies. Design concept and prototype studies (18;23;36;37;39;41;42) do not give input. The repeated usability studies from Panagopoulos et al. may have given hints regarding how the technology could be adapted over time (34;35), however, no conclusions regarding the embedding in real application contexts can be derived.

laws, practices, and traditions shape health care, there may be more publications in other languages. Furthermore, by only including publications between 2008 and spring 2019, relevant publications covering evaluations of mHCA interventions outside that period may have been missed. Nevertheless, the period was deliberately chosen to minimize technology bias. Furthermore, due to the specific focus of this study, numerous studies analyzing solely the needs and requirements of technology introductions could not be considered.

Practical Implications

This analysis suggests that mHCA are capable of reducing the psychological burden on informal caregivers ("peace of mind" (23)) but that the applications can only develop their full potential if they are used in large networks involving various interdisciplinary actors (42). However, because it is not yet clear whether electronic communication will create additional workload in terms of hours and other types of informal help, or whether it rather ameliorates the quality of life of patients and caregivers (41), researchers have so far refrained from drawing implications for practice. Depending on the condition of the elderly patients living at home as well as their care networks, the advantages of a simple communication system may outweigh complex collaboration systems. Further research is needed to examine the impact of using mHCA on the care burden of informal caregivers, the quality of care and quality of life of the home-dwelling elderly (41). For example, the use of "Smart Toys" (18) may stimulate and facilitate proactive interaction among elderly patients and mHCA interventions may be particularly useful for informal caregivers (18). However, as long as the systems are at the prototype level and

no seamless interoperability with existing digital communication and coordination tools is in place, these applications cause extra effort and are unlikely to be adopted. To solve "infrastructural work" (44) problems and thus provide a systemic basis for the introduction of the technology, examples, such as the Buurtzorg model (45) should be consulted.

Implications for Research

Several publications address the target group's needs and requirements with design proposals (c.f. (4;22;24;46)), but due to low maturity levels, the adoption aspects are rarely evaluated. Additional research is needed to examine the change processes that accompany the adoption process of home care-specific collaboration applications.

The design and implementation of new technology is time-consuming and difficult, thus, evaluations of prototypes are rare. In addition, it is most likely that reports of unsuccessful field studies are not published. Research investigating change management in the adoption of new technologies needs to be given higher priority to close the gap between commercially successful applications and the scientific proof of the effect of such applications.

The need to enhance collaboration in mixed home care is evident, but the use of care-specific technologies and their positive impacts on the stabilization of care arrangements has yet to be demonstrated. Because field tests with target networks have proven difficult, it could be helpful to investigate the user experience of successful application launches (e.g., by text-mining user rating posts) to support the further development of mHCA and promote their positive effects in Europe. Further analysis and

categorization of care networks could help to identify those care network types that are more receptive to technology use and usage benefits. More specific testing could then be carried out in networks with high usage potential and the tests could be evaluated using standardized assessment instruments.

It is unclear whether care-specific software is needed or whether general collaboration tools would provide the same value. In addition, practical implementation issues still need to be clarified, for example, who would ideally operate a care-specific software platform.

References

1. **Statistisches Bundesamt**. *Pflegestatistik 2017—Pflege im Rahmen der Pflegeversicherung Deutschlandergebnisse*. Wiesbaden: Statistisches Bundesamt; 2018.

2. **Granovetter MS**. The strength of weak ties. *Am J Sociol*. 1973;**78**:1360–80.

3. **Eggert S, Sulmann D, Teubner DC.** ZQP-Befragung: Einstellung der Bevölkerung zu digitaler Unterstützung in der Pflege. Berlin; 2018. Available from: https://www.zqp.de/wp-content/uploads/ZQP_Analyse_Pflege Digitalisierung.pdf.

4. **Renyi M, Rosner M, Teuteberg F, Kunze C.** Collaboration in mixed homecare—A study of care actors' acceptance towards supportive groupware. In: Abramowicz W. Corchuelo R, editors. Business information systems BIS 2019 lecture notes in business information processing, vol. 354. Cham: Springer; 2019, 269–83.

5. **Consolvo S, Roessler P**. Technology for care networks of elders. *IEEE Pervasive Comput*. 2004;**3**:22–29.

6. **Winge M, Wangler B, Johansson L, Nyström M, Waterworth E.** CO-CARE—Collaborative health and social care. In: Bath P, Day K, Norris T, editors. 13th International symposium for health information management research. Auckland, New Zealand; 2008, p. 113–24.

7. **Winge M, Wangler B.** Needs, requirements and e-services for collaborative and patient-centered care. In: Aseeva N, Babkin E, Kozyrev O, editors. Emerging topics in business informatics research 2012—Proceedings of the 11th international conference, BIR 2012, Nizhny Novgorod, Russia, September 24–26, 2012. CEUR Workshop Proceedings, ISSN 1613-0073, 963; 2012, p. 75–91.

8. **Winge M, Johansson L-Å, Lindh-Waterworth E, Nyström M, Wangler B.** A new care concept—Making collaborative home care work. In: Nummenmaa J, Söderström E, editors. Proceedings of the 6th international conference on perspectives in business information research—BIR2007, Tampere: Department of Computer Sciences University of Tampere; 2007, p. 158–69.

9. **Koch S, Hägglund M, Scandurra I, Moström D.** Old@Home-Technical support for mobile close care, Final report. Vol. 14, Vinnova Report. 2005. VINNOVA—Swedish Agency for Innovation Systems/Verket för Innovatonssystem; 2005.

10. **Scandurra I, Hägglund M, Koch S**. From user needs to system specifications: Multi-disciplinary thematic seminars as a collaborative design method for development of health information systems. *J Biomed Inform*. 2008;**41**:557–69.

11. **Hägglund M, Scandurra I, Moström D, Koch S.** Bridging the gap: A virtual health record for integrated home care. *Int J Integr Care*. 2007;**7**:e26.

12. **Hägglund M, Scandurra I, Koch S.** Studying intersection points—An analysis of information needs in shared homecare of elderly. *J Inf Technol Healthc*. 2009;**7**:1–20.

13. **Phung HM, Hoang DB, Lawrence E.** A novel collaborative grid framework for distributed healthcare. In: Cappello F, Wang C, Buyya R, editors. Proceedings of the 9th IEEE/ACM international symposium on cluster computing and the grid, CCGrid 2009, Shanghai, China, 18–21 May 2009. IEEE Computer Society 2009; 2009. ISBN 978-0-7695-3622-4, p. 514–19.

14. **Renyi M, Teuteberg F, Kunze C.** ICT-based support for the collaboration of formal and informal caregivers—A user-centered design study. In: Abramowicz W. Paschke A, editors. Business information systems BIS 2018 lecture notes in business information processing, vol. 320. Cham: Springer; 2018, p. 400–11.

15. **Fabiano A, de Carvalho P, Tellioğlu H, Hensely-Schinkinger S, Habiger M**. Supporting informal carers' independency through coordinated care. In: de Angeli A, Bannon L, Marti P, Brodin S, editors COOP 2016: Proceedings of the 12th international conference on the design of cooperative systems, 23–27 May 2016, Trento, Italy: Springer International Publishing, p. 155–72.

16. **Renyi M, Kunze C, Rau S, Rosner M, Gaugisch P** (2017) Digitalisierung in Hilfemix-Strukturen: IT-Systeme zur Koordination von Versorgungsnetzwerken mit professionellen und informellen Pflegenden. In: Pfannstiel MA, Krammer S, Swoboda W, eds. Digitale Transformation von Dienstleistungen im Gesundheitswesen III. Wiesbaden: Springer Fachmedien Wiesbaden GmbH; 2017. p. 201–20.

17. **GooglePlay**. CareBetter. Available from: https://play.google.com/store/apps/details?id=com.app.carebetterb [accessed 2019 Jul 28].

18. **Garcia AC, de Lara SMA.** Enabling aid in remote care for elderly people via mobile devices: The MobiCare case study. In: *Proceedings of the 8th international conference on software development and technologies for enhancing accessibility and fighting info-exclusion*, June 20–22, 2018—Aristotle University of Thessaloniki, Greece—DSAI'18, New York, USA: ACM Press; 2018, p. 270–77.

19. **CareZoneInc**. CareZone. Available from: https://carezone.com/ [accessed 2019 Jul 28].

20. **Carers UK**. Jointly. Available from: https://www.jointlyapp.com/ [accessed 2019 Jul 28].

21. **CaringBridge**. Caring Bridge. Available from: https://www.caringbridge.org [accessed 2019 Jul 28].

22. **Verdezoto NX, Wolff Olsen J.** Personalized medication management: Towards a design of individualized support for elderly citizens at home. In: Luo G, Liu J, Yang CC. Proceedings of the 2nd ACM SIGHIT symposium on international health informatics—IHI'12. New York, USA: ACM Press; 2012, p. 813–18.

23. **Bossen C, Christensen LR, Grönvall E, Vestergaard LS**. Carecoor: Augmenting the coordination of cooperative home care work. *Int J Med Inform*. 2013;**82**:e189–99.

24. **Schorch M, Wan L, Randall DW, Wulf V.** Designing for those who are overlooked—Insider perspectives on care practices and cooperative work of elderly informal caregivers. In: *CSCW'16 proceedings of the 19th ACM conference on computer-supported cooperative work & social computing*. New York, USA: ACM Press; 2016, p. 787–99.

25. **Amsha KA, Lewkowicz M.** Shifting patterns in home care work: Supporting collaboration among self-employed care actors. In: de Angeli A, Bannon L, Marti P, Bordin S, editors. COOP 2016: Proceedings of the 12th international conference on the design of cooperative systems. Trento, Italy: Springer International Publishing; 2016, p. 139–54.

26. **Baldissera TA, Camarinha-Matos LM.** Services personalization approach for a collaborative care ecosystem. In: Afsarmanesh H, Camarinha-Matos LM, Soares AL, editors. 17th IFIP WG 55 working conference on virtual enterprises, PRO-VE 2016. Porto, Portugal: Springer International Publishing Switzerland; 2016, p. 443–56.

27. **Carers UK**. Carers app wins key business and local government support. UK press releases; 2014. Available from: https://www.carersuk.org/news-and-campaigns/press-releases/carers-app-wins-key-business-and-local-government-support [accessed 2019 Jul 28].

28. **Craig P, Dieppe P, Macintyre S, Michiel S, Petticrew, M**. Medical research council guidance. Developing and evaluating complex interventions: The new medical research council guidance. *BMJ*. 2008;**29**:a1655. doi: 10.1136/bmj.a1655.

29. **Greenhalgh T, Wherton J, Papoutsi C, Lynch J, Hughes G, A'Court C et al.** Beyond adoption: A new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies. *J Med Internet Res.* 2017;**19**:e367.

30. **Greenhalgh T, Wherton J, Papoutsi C, Lynch J, Hughes G, A'Court C, Hinder S, Procter R, Shaw S**. Analysing the role of complexity in explaining the fortunes of technology programmes: Empirical application of the NASSS framework. *BMC Med.* 2018;**16**:66.

31. **Greenhalgh T, Abimbola S**. The NASSS framework a synthesis of multiple theories of technology implementation. *Stud Health Technol Inform.* 2019;**263**:193–204.

32. **Moher D, Liberati A, Tetzlaff J, Altman DG**. PRISMA group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med.* 2009;**6**:e1000097.

33. **CASP Checklists—CASP—Critical Appraisal Skills Programme**. Available from: https://casp-uk.net/casp-tools-checklists/ [accessed 2019 Sep 6].

34. **Panagopoulos C, Kalatha E, Tsanakas P, Maglogiannis I.** Evaluation of a mobile home care platform lessons learned and practical guidelines. In: de Ruyter B, Kameas A, Chatzimisios P, Mavrommati I, editors. Ambient intelligence proceedings of the 12th European conference, AMI 2015, Athens, Greece, November 11–13, 2015, Lecture Notes in Computer Science. Cham: Springer. 9425; 2015, p. 328–43.

35. **Panagopoulos C, Menychtas A, Tsanakas P, Maglogiannis I**. Increasing usability of homecare applications for older adults: A case study. *Designs.* 2019;**3**:23.

36. **Riche Y, Mackay W**. Peercare: Supporting awareness of rhythms and routines for better aging in place. *Comput Support Coop Work.* 2010;**19**:73–104.

37. **Alkhushayni S**. *mHealth technology: Towards a new persuasive mobile application for caregivers that addresses motivation and usability*. Theses and Dissertations. University of Wisconsin-Milwaukee; 2016, p. 1330, Available from: https://dc.uwm.edu/etd/1330.

38. **Patrick AY**. *Baby Boomer Adoption of Healthcare Apps*. Master's Thesis, East Carolina University; 2016. Available from: http://hdl.handle.net/10342/5354.

39. **Boessen ABCG, Verwey R, Duymelinck S, van Rossum E**. An online platform to support the network of caregivers of people with dementia. *J Aging Res.* 2017;**2017**:3076859.

40. **Goubran M.** *Evaluation of the Use of a Touchscreen Assistive Device for People with Dementia: A Pilot Study*. Master Thesis, University of Ottawa; 2017.

41. **Breebaart H, Broese van Groenou M.** A groupware tool to facilitate caregiving for home-dwelling frail older persons in the Netherlands: Mixed-methods study. *JMIR Aging.* 2018;**1**(2):e10697.

42. **Drugbert L, Labadie N, Tixier M** (2018) Aidadom: Supporting inter-organizational coordination for home help and healthcare services through a web platform. *IRBM*. **39**:386–93.

43. **Martinez M, Ye B, Mihailidis A**. Usability of a care coordination application to ease family caregiver burden: A dementia case study. *Gerontechnology.* 2018;**17**:181–93.

44. **Gui X, Chen Y.** Making healthcare infrastructure work: Unpacking the infrastructuring work of individuals. In: Brewster S, Fitzpatrick G. Proceedings of CHI'19: CHI conference on human factors in computing systems. New York, USA: ACM Press, 2019, p. 1–14. doi: 10.1145/3290605.3300688.

45. **Nandram SS**. Integrating simplification theory for navigating the VUCA: The case of Buurtzorg Nederland. In: Nandram SS, Bindlish PK, editors. Managing VUCA through integrative self-management. Management for professionals. Cham: Springer International Publishing; 2017, p. 263–87.

46. **Bratteteig T, Wagner I.** Moving healthcare to the home: The work to make homecare work. In: Bertelsen OW, Ciolf L, Grasso iMaria A, Papadopoulos GA, eds. ECSCW 2013: Proceedings of the 13th european conference on computer supported cooperative work, 21–25 September 2013, Paphos, Cyprus. London: Springer-Verlag London; 2013, p. 143–62.