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Mirbabaie, Milad; Stieglitz, Stefan; Frick, Nicholas R. J.

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# Hybrid intelligence in hospitals: towards a research agenda for collaboration

Milad Mirbabaie<sup>1</sup> · Stefan Stieglitz<sup>2</sup> · Nicholas R. J. Frick<sup>2</sup>

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## Abstract

Successful collaboration between clinicians is particularly relevant regarding the quality of care process. In this context, the utilization of hybrid intelligence, such as conversational agents (CAs), is a reasonable approach for the coordination of diverse tasks. While there is a great deal of literature involving collaboration, little effort has been made to integrate previous findings and evaluate research when applying CAs in hospitals. By conducting an extended and systematic literature review and semi-structured expert interviews, we identified four major challenges and derived propositions where in-depth research is needed: 1) audience and interdependency; 2) connectivity and embodiment; 3) trust and transparency; and 4) security, privacy, and ethics. The results are helpful for researchers as we discuss directions for future research on CAs for collaboration in a hospital setting enhancing team performance. Practitioners will be able to understand which difficulties must be considered before the actual application of CAs.

**Keywords** Hybrid intelligence · Conversational agents · Hospitals · Collaboration · Research agenda · Coordination

**JEL classifications** I00

## Introduction

The introduction of conversational agents (CAs) holds immense potential for hospitals (e.g., Han and Yang 2018; Laranjo et al. 2018; Seeger et al. 2017) to improve collaboration between medical professionals and the coordination of health-related tasks (Georgiadis 2011; Just et al. 2005).

Hospitals aim to enhance the overall service quality and levels, ultimately providing better medical care for patients (Majeed Alhashem et al. 2011). The quality of healthcare is described as subjective, complex and of multidimensional perception influenced by several factors (Mosadeghrad 2014). Besides professional skills (e.g., competence of clinicians) or medical experiences (e.g., physicians having sufficient expertise), interpersonal factors regarding human resources are vital (Mosadeghrad 2013). Thereby, the exchange of information and the degree of interaction between clinicians are explained as major criteria (Handayani et al. 2015). Mosadeghrad (2014) expresses that clinicians' competence to effectively communicate and collaborate with other healthcare specialists is essential to deliver high-quality healthcare services. Reaching effective communication and collaboration requires the involvement and coordination of different healthcare professionals who follow various norms or specifications with ranging roles from multiple departments (Charette 2006; Platt et al. 2019). However, clinicians largely manage their tasks in isolation with a lack of mutual understanding and cooperation. This silo thinking hinders sharing knowledge across departmental boundaries (McCracken and Edwards 2017), preventing collaboration between multiple disciplines and encourages competitive behavior (Driscoll et al. 2015). High

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✉ Milad Mirbabaie  
milad.mirbabaie@uni-bremen.de

Stefan Stieglitz  
stefan.stieglitz@uni-due.de

Nicholas R. J. Frick  
nicholas.frick@uni-due.de

<sup>1</sup> Department of Business Studies and Economics, University of Bremen, 28359 Bremen, Germany

<sup>2</sup> Professional Communication in Electronic Media / Social Media, University of Duisburg-Essen, 47057 Duisburg, Germany

administrative effort leads to delays in the treatment process for which departments blame each other (Giroto et al. 2010) and expose patients to potential safety hazards when transferring them between disciplines (Driscoll et al. 2015). Goal-oriented collaboration among hospital employees is a key aspect in managing the coordination of tasks and thus mitigating errors during the treatment process creating safe systems of care delivery (Babiker et al. 2014; Rosen et al. 2018). Collaboration and information exchange is of great relevance to coordinate tasks and to ensure accurate, safe, and effective patient treatment (Gilbert et al. 2010; McInnes et al. 2015).

Interacting with CAs facilitates collaboration and promotes the coordination of health-related tasks (Georgiadis 2011; Just et al. 2005). For example, CAs monitor patient's overall health conditions to support the healing and regeneration processes (Pereira et al. 2013), improve the accuracy and timeliness of treatment (Atherton et al. 2013), and enhance the diagnostic and therapeutic process (Ferlie and Shortell 2001). The application of CAs also leads to effective team building and better team spirit among colleagues (Bittner, Küstermann, et al., 2019; Dyke et al. 2013; Strohmann et al. 2018). These improvements are especially beneficial in hospitals for the collaborative diagnosis of diseases and the development of treatment plans across multiple departments without the need for peer to peer collaboration. The development of CAs is enabled by artificial intelligence (AI) as building systems become more practicable (Knijnenburg and Willemsen 2016; Luger and Sellen 2016). CAs are initially intelligent systems interacting with and augmenting humans' abilities (McTear et al. 2016). However, there are different aspects of intelligent behavior. First, there are systems that respond to a certain input with a simple predefined reaction or reflex (Russel and Norvig 2016). Second, there are agents, which are lying within the scope of this research, that continuously learn and develop over time (Mitchell et al. 2018). Such learning agents acquire information through different types of knowledge and input or by multiple years of experience (Mitchell et al. 2018). Since interactions with CAs aim to combine the complementary strengths of users and AI (Kamar 2016; Maedche et al. 2019), they can be considered a subset of hybrid intelligence (Dellermann et al. 2019a), a concept with "the ability to achieve complex goals by combining human and artificial intelligence, thereby reaching superior results to those each of them could have accomplished separately, and continuously improve by the ongoing learning from each other" (Dellermann et al. 2019b, p. 4). Complementary strengths explain the different capabilities of humans and CAs. Humans possess emotional intelligence and the ability to empathize with others; are creative, think outside the box, and develop possibilities for innovations; are flexible, adapt to different or unexpected situations, and take responsibility. CAs, on the contrary, are fruitful for tackling repetitive tasks, which require the fast retrieval and processing of huge amounts of digital information and the interpretation of complex interdependencies (Dellermann et al. 2019b). Hybrid

intelligence is described by the following three main concepts (Dellermann et al. 2019b): Collectively explains that tasks are solved together by humans and systems. Superior results refer to the performance on jointly solved tasks being better compared to solving a problem alone. Continuous learning characterizes that both humans and systems develop and improve over time by learning from each other through experience. Hybrid intelligence and therefore CAs provide humans with input, which is evaluated to make a decision (e.g., AI in the loop of human intelligence), and humans provide CAs with input to make them more effective (e.g., human intelligence in the loop of AI) (Dellermann et al. 2018; Dellermann et al. 2019b).

Hospitals have distinctive domain-specific requirements for the coordination of tasks (Aanestad and Vassilakopoulou 2019; Hanseth and Bygstad 2015). The interaction between healthcare specialists and CAs is suitable for tackling these issues (Seeber et al. 2018), for example, by providing the most relevant information to hospital employees to fulfill a duty without any delay (Diederich et al. 2019; Preece et al. 2017). Information systems (IS) are currently insufficiently integrated into the daily clinical routine, where medical information is distributed over several databases (Meier et al. 2014) and the vast amount of information is difficult to handle (Prados-Suárez et al. 2012). CAs are able to obtain relevant data immediately as they are capable of better understanding complex interdependencies and gathering relevant information quicker than humans (Nasirian et al. 2017). The increasing capabilities of CAs lead to the pressing need of rethinking their collaboration with humans within the IS discipline. The complexity of the overall treatment process and the obligation of hospitals to decrease expenses drives the demand to explore new opportunities to enhance collaboration (Klinker et al. 2019; McInnes et al. 2015). It is necessary to consider CAs in terms of their phenomenon of improving collaboration and their capability of the coordination of diverse tasks (Dellermann et al. 2019b; Seeber et al. 2018). CAs offer novel challenges for collaboration and task coordination, including extending expertise and the joint completion of tasks (Dellermann et al. 2019b). The introduction of CAs has the potential to improve collaborative processes within hospitals; however, exploring new functionalities of healthcare information technology has proven to be demanding for IS research (Romanow and Straub 2012).

Undesirable outcomes as a result of failures in collaboration might have disastrous consequences for the patient's health condition (Jain 2006; Leonard 2004). If CAs become widely used to improve collaboration, they could feasibly coordinate different tasks and not just be of great value for applications in hospitals but also for the patients' general well-being. However, a full conceptualization of the challenges when introducing CAs to improve collaboration in hospitals is still lacking. We argue that this is of great interest to researchers and practitioners since its relevance will increase even further. Despite CAs' potential, there is not enough

research conducted on the exploration of the challenges in a team setting (Diederich et al. 2019). There is a pressing need for the IS discipline to provide an overview of the challenges for understanding the complexity of the application of CAs in hospitals. In addition, an agenda that gives special consideration regarding what research is needed to successfully establish CAs for this purpose is overdue. To address these urgent issues, our study is guided by the following research question:

RQ: How does the interaction between humans and conversational agents affect the quality of care process?

We carried out a systematic literature review (SLR) because the complexity of the interaction between humans and CAs has not yet been adequately covered in the extant research, and there is no overview of the major challenges that appear when CAs are introduced in hospitals. This descriptive approach examined pre-existing literature describing the current situation based on scientific facts (Bear and Knobe 2016; Bell 1989) and summarized the findings under a suitable heading where literature has dealt with identical or similar issues. We further conducted expert interviews to discover the consequences of the reviewed challenges. In this prescriptive procedure, the experts described impacts of existing problems, defined how obstacles should be addressed, and recommended purposeful actions (Bear and Knobe 2016; Bell 1989).

This paper contributes by structuring our understanding of collaboration and difficulties of CAs in hospitals. Researchers will find the overview of challenges helpful to consider potential difficulties before the actual introduction of CAs. To guide researchers' efforts, we outline an agenda explaining where future research of CAs and collaboration within hospitals seems promising. Practitioners will be able to understand the extent to which CAs improve collaboration and how hospitals, stakeholders and patients benefit. This article seeks to extend the IS literature by identifying areas that need further investigation and challenges that have not yet been adequately addressed.

## Related work

### Collaboration in clinical environments

Collaboration is a key factor in coordinating tasks and ensuring accurate and punctual treatment to achieve safe and effective patient care (Gilbert et al. 2010; McInnes et al. 2015). McInnes et al. (2015) propose three factors affecting collaboration and teamwork between hospital employees: 1) roles and responsibilities; 2) respect, trust, and communication; and 3) hierarchy, education, and liability. Understanding and respecting the roles of colleagues is important for effective collaboration (Besner et al. 2011; Sargeant et al. 2008), improving care as well as patient outcomes (Barrett et al. 2007; Brault et al. 2014). Trust in each other's work, respect, and proper communication are factors for favorable collaboration and

performance improvements (Schadewaldt et al. 2013, 2014). Hierarchical structures limit the collaboration between nurses and physicians (Finlayson and Raymont 2012) and know-how for coordinating patient care is a premise for performance improvements (Sargeant et al. 2008). In addition to the three dimensions, it is important to distinguish between 1) organizational processes and 2) the medical treatment process as two separate kinds of collaboration (Lenz and Reichert 2007). Organizational processes help to coordinate the interaction between healthcare professionals and organizational units, whereas the medical treatment process focuses on the patient and diagnostic and therapeutic procedures.

There is a strong correlation between effective collaboration and team-building among health professionals and patients' medical treatment (Iya et al. 2017). Team-building positively influences clinical performance (Orledge et al. 2012; Tschan et al. 2006, 2009) as group development in hospitals facilitates team performance (Klein et al. 2009; Tannenbaum et al. 1992). Decisions made by teams with members who anticipate the needs of other collaborators (Iya et al. 2017) are superior to individual judgments and contain fewer mistakes (Salas et al. 2005; Smith-Jentsch et al. 2001). Team-building can be subdivided into 1) goal setting, 2) interpersonal relations, 3) problem solving, and 4) role clarification (Beer 1980; Buller and Bell 1986). Goal setting emphasizes the importance of goals that determine what the whole team strives to contribute (Leggat 2007; Salas et al. 1999), helps the team choose the correct approach, and affects the duration of and the effort expended in an action (Aga et al. 2016; Buller and Bell 1986). Interpersonal relations are unavoidable, and they involve increased supportiveness, confidence, and communication (Amos et al. 2005; Salas et al. 1999). Problem solving facilitates goal setting as every team member is involved in action planning to implement resolved solutions (Ezziane et al. 2012; Salas et al. 1999). Role clarification emphasizes the clear distribution of individual responsibilities and fixed roles within a team to reduce the probability of errors (Salas et al. 2005; Smith-Jentsch et al. 2001).

Collaboration and team-building are interdependent factors that facilitate frictionless processes in hospitals. On the one hand, incorrect or poor collaboration among employees has a negative effect on the team spirit. On the other hand, collaboration is weakened if team members do not work well together. The best results are therefore achieved by teams in which the atmosphere is perceived as positive and where collaboration among members is successful. However, there are common issues frequently experienced by clinicians in the context of collaboration and team-building:

- 1) Communication (insufficient – sufficient): Faulty information exchange is a major problem, not only between healthcare specialists and patients, but also among hospital employees (Kripalani et al. 2007). Insufficient

communication among clinicians generally hinders accurate diagnosis and treatment, while sufficient communication is desirable for achieving a seamless care process (Balogh et al. 2015).

- 2) Responsibilities (opaque – clear): Physicians constantly face changing responsibilities, with a range of roles, and are frequently interrupted (Rosen et al. 2018; Wears and Berg 2005). It is not always possible to reach out for the most suitable experts in adequate time; the integration of multiple specialists is not straightforward, as medical information is not consistently available, possibly leading to different health-related conclusions.
- 3) Infrastructure (complex – simple): Treatment durations are extensive because clinicians' searches for information across multiple systems are time-consuming (Meier et al. 2014). Hospitals operate in complex clinical environments, with a wide range of systems containing different information; systems are not interconnected and operated by multiple professionals (Angst et al. 2010; Hanseth and Bygstad 2015). Simple and consistent presentation of medical data accelerates the treatment process.
- 4) Decisions (subjective – objective): Diagnosing and treating different diseases is strongly subjective, depending on individual experience and differing based on clinicians' emotions and mental states (Chang and Hsu 2009; Singh et al. 2020). This applies to experienced professionals and actors with different levels of expertise, e.g., young assistant doctors with limited clinical educations (Laurenzi et al. 2017; Singh et al. 2020). Even though clinicians try to derive objective decisions, they always act with subjective influence and own judgments.

Issues in the context of collaboration and team-building lead to insufficient medical decisions. Tackling these issues within hospitals presupposes the integration of suitable technologies such as CAs to improve team performance and thus the quality of care process and treatment of patients (Gopal et al. 2018; Klinker et al. 2019).

### Conversational agents as hybrid intelligence

Research has focused on CAs in various disciplines (Brachten et al. 2018; Saffarizadeh et al. 2017; Seeber et al. 2018; Wunderlich and Paluch 2017), explaining them from different perspectives (Luger and Sellen 2016; von der Pütten et al. 2010). CAs can be classified along (Gnewuch et al. 2017) their primary mode of communication (how users interact with CAs, e.g., text-based or speech-based input) (Lee et al. 2009) and their main purpose (narrowed down to one task or used for a general context) (Nunamaker et al. 2011). However, there are overlaps in functionalities and alternative perspectives for classifications. CAs might be expanded to fit individual requirements or tasks (Chung et al. 2017), or text-based systems might

use speech-to-text modules to convert human language (Gnewuch et al. 2017). Studies also distinguish between certain design characteristics as adaptivity (e.g., learning by analyzing and interpreting data and adjust to changed circumstances) or assistance domain (e.g., the context in which an agent provides appropriate assistance) (Knote et al. 2019). Furthermore, research identified additional effects on, for example, trust and its effects for collaboration where factors such as human-likeness or self-presentation influence the willingness to collaborate with CAs (Følstad et al. 2018). There are various approaches to define CAs but without emerging a consistent solution. Luger and Sellen (2016) define CAs as “IS that enable the interaction with users via natural language” (p. 5287), Laumer et al. (2019) describe CAs as “text-based and voice-based automated dialog systems that can interact with a human user via natural language and answer questions on specific topics” (p. 2). We argue that these explanations are rather limiting the actual functionalities of CAs and thus define CAs as dialog systems simulating the behavior of humans via different modes of communication (e.g., written or spoken natural language, haptics, gestures, facial expressions, graphics), continuously learn and develop over time by analyzing and interpreting a given input combined with additional data sources for assisting with divergent tasks or execute them autonomously.

CAs receive increasing attention due to the constant progress of AI (Berg 2015; Spohrer and Banavar 2015). Building systems using underlying machine learning algorithms became more practicable (Knijnenburg and Willemsen 2016; Luger and Sellen 2016) as technical capabilities improved while costs decreased (Spohrer and Banavar 2015). Since CAs combine the complementary strengths of humans and AI (Kamar 2016), they represent a subset of hybrid intelligence (Dellermann et al. 2019a). Humans provide CAs with input to make them more effective, CAs provide humans with input to assist with decisions. Unlike regular IT or decision support systems, CAs are adaptive and behave reactively, proactively and autonomously (Meyer von Wolff et al. 2019). CAs continuously self-learn and develop over time by processing context information and user input (Mitchell et al. 2018). Furthermore, CAs handle tasks via dialogues, using written or spoken natural language, as well as interpreting gestures or facial expressions (Laumer et al. 2019; Nakano and Fukuhara 2012). CAs can also differentiate between and interpret the emotions of individuals within team communication (McDuff and Czerwinski 2018) and use different language styles to adapt to users (Gnewuch et al. 2020). These methods create a natural way of communication, in which users feel like talking to another human, thus indicating that CAs are inherently anthropomorphic (Feine et al. 2019; Hussain et al. 2019; Pfeuffer et al. 2019). Research further demonstrates that CAs are able to assist in decision making (Seeber et al. 2020b; Waizenegger et al. 2020) and are perceived as legitimate team members (Seeber et al. 2018).

There is still a big difference in the level of capabilities CAs exhibit. Most CAs do not have a particular embodiment but are integrated into existing IS and interact with users via simple, natural language (Diederich et al. 2019). Currently deployed CAs are particularly useful for highly standardized processes or repetitive procedures, thus are rather domain-specific focusing on a narrow task (Batin et al. 2017; Knotte et al. 2019). Results provided by CAs are generated according to an explicit pattern (Brachten et al. 2020; Mirbabaie et al. 2020). More complex contexts are still jointly solved with humans (Maedche et al. 2019). However, using the complementary strengths of CAs and humans to achieve complex goals while continuously learn from each other and develop over time, i.e., the concept of hybrid intelligence, yields in superior results (Dellermann et al. 2019b). Even though we are still far away from empathy-driven, creative robot teammates, we argue that integrating CAs as flexible communication partners into the daily routine of hospitals improves collaboration.

### Conversational agents in hospitals

CAs in hospitals are beneficial in many areas but have mainly focused on the assistance of patients, e.g., in chronic disease self-care management (Kimani et al. 2016) or supporting diabetes patients in their daily routines (Shaked 2017), as systems are more successful performing health-related tasks compared to conventional interfaces (Bickmore et al. 2016). Besides, CAs are able to solve common problems in hospitals by enhancing collaboration and team-building among employees (Georgiadis 2011; Pynadath and Tambe 2003). Insufficient communication is countered through properly reported decision support based on medical information, excluding improper and incorrect communication among involved specialists. CAs are capable of adapting to different users with varying roles (Gnewuch et al. 2020; Pfeuffer et al. 2019) possibly leading to appropriate patient treatment and performance improvements in therapeutic processes (Schadewaldt et al. 2013, 2014). Opaque responsibilities are solved as CAs provide information about healthcare professionals' responsibilities (Traum et al. 2003). By continuously learning and developing, CAs act proactively and autonomously (Meyer von Wolff et al. 2019) enabling identifying rotating medical experts more easily and creating transparency (Bickmore et al. 2011; Kerly et al. 2007). Complex infrastructure is simplified since CAs assist in fulfilling tasks by providing the most suitable information and type of communication for their users (Laumer et al. 2019; Preece et al. 2017). CAs retrieve relevant medical information from multiple sources rapidly (Nasirian et al. 2017), merge information to present it in the manner most suited to their users thus reducing the handling time of medical duties to a minimum. Subjective decisions are excluded because CAs provide objective conclusions and evaluate patients' conditions based on medical facts from multiple years

of experience (Mitchell et al. 2018). CAs do not depend on situations, emotions, or time of day (Gnewuch et al. 2017); they reach equal decisions when using identical medical data. An overview on common collaborative challenges clinicians frequently face in hospitals and the potential for CAs can be found in the appendix (Table 3).

We believe that CAs hold the potential to moderate collaborative challenges, for example, by providing communicative support through user-oriented interaction (Gnewuch et al. 2020; Pfeuffer et al. 2019) or delivering suitable medical information by learning and adapting to varying circumstances (Mitchell et al. 2018). With their unique capabilities, i.e., using social cues (Feine et al. 2019) and interpreting facial expressions, gestures and emotions (McDuff and Czerwinski 2018; Pfeuffer et al. 2019), CAs are also able to improve the overall team performance. Based on these assumptions, we derived a preliminary research model as depicted in Fig. 1.

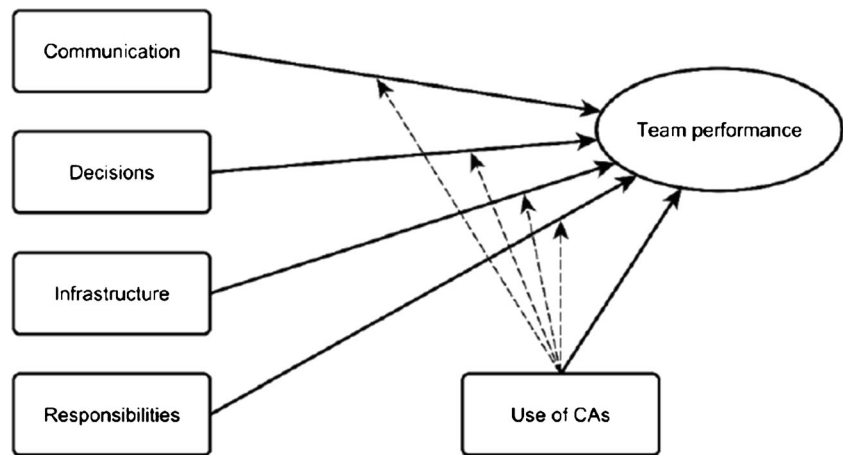
CAs in hospitals are not just simple tools to perform narrow duties but can rather be seen as teammates collectively working with humans to achieve superior results (Dellermann et al. 2019b; Seeber et al. 2020a). However, there is still a lack in conceptualizing the challenges when introducing CAs in a team setting to improve collaboration in hospitals.

## Research approach

### Systematic literature review

Since CAs in hospitals are a relatively new research area, we argue that it will benefit from an accurate categorization transferring existing findings from related scientific streams. We thus decided to conduct a systematic approach for searching relevant literature to answer our research question. A SLR is suitable for tackling emerging issues, identifying knowledge about a topic including its gaps and supporting researchers in emphasizing their contribution of knowledge, by searching for relevant articles in scientific databases using keywords (Temple 2006; Webster and Watson 2002). Our research approach is divided into three steps. First, we use theoretical foundations, as suggested by McInnes et al. (2015), Lenz and Reichert (2007) and Salas et al. (1999), for classifying the existing research along the main characteristics of collaboration and team-building. The five categories on collaboration and the four categories on team-building served as a coherent conceptual pre-structure in which the literature was roughly categorized (Bem 1995). In the next step, we examined and compared the retrieved literature to identify correlations and similarities. Prior research was grouped into a categorization among the theoretical foundations. In the final step, we identified major challenges as well as implications for further research that should be pursued to successfully establish CAs for collaboration and team-building in hospitals.

**Fig. 1** Preliminary research model



Following the literature review process (vom Brocke et al. 2009, 2015), we defined our research scope based on the taxonomy of literature reviews (Cooper 1988). We were interested in research focusing on different applications of CAs to adopt findings for their application in hospitals. The literature search considered all conference publications as well as journal articles from five bibliographic databases from the fields of computer science (ACM, IEEE, AISel, SD, JSTOR). Less relevant sources, such as editorials, were excluded. To avoid overlooking relevant literature, we carried out a full-text and metadata search in every database, not limiting the search to metadata only as it cannot be guaranteed that search terms are contained in the metadata. Furthermore, not every abstract of each article is stored and accessible in the databases. Since there are various notations for the term “conversational agents” that are used interchangeably (Luger and Sellen 2016), we linked the most common ones within the search string “chat-bot”, “chatbot” and “virtual agent”. This expression was then combined with the terms “collaboration” and the different spellings of “team-building”. We finally used the following query:

((“Conversational Agent” OR Chat-Bot OR Chatbot OR “Virtual Agent”) AND (Collaboration OR Team-Building OR Teambuilding))

Parentheses are used to nest clauses or to group phrases. Separate statements are linked by Boolean expressions, and quotation marks are used to specify terms which must appear next to each other. After retrieving the literature, we carefully read the title, abstract, and keywords of each publication to determine its relevance according to our research question. We then categorized the literature according to the theoretical foundations about collaboration and team-building (for example statements and exemplary assignment, please see appendix, Table 5). Next, we performed a backward search to find additional papers by collecting all references of each paper’s bibliography to other scientific publications. To determine the paper’s relevance, we again read the title, abstract, and keywords followed by categorization according to the

theoretical foundations. As the last step, we conducted a forward search to further identify relevant literature, acknowledging all papers that had been retrieved in the database as well as in the backward search. Therefore, we were interested in articles that have been cited by other research after their initial publication. Once more, we read the title, abstract, and keywords and performed the categorization process as outlined above.

### Semi-structured expert interviews

To highlight the consequences for the identified major challenges, we conducted semi-structured expert interviews with individuals having advanced knowledge in the investigated field of research (Meuser and Nagel 2009). We followed the approach of Meuser and Nagel (2009), who consider an open interview, supported by a prefixed guideline, as the most applicable way for retrieving valuable data while providing participants with enough room for elaborating their own subjective beliefs. We recruited hospital employees working in teams thus are able to judge from their own experience of collaboration and team-building. Furthermore, experts from the practice provided an unbiased picture of the actual situation and occurring problems. We acquired four physicians with diverse specialties and disciplines with varying training levels, enabling us to gain insights into various areas to broaden our view on collaboration and team-building in hospitals. Additionally, we carried out interviews with computer scientists experienced in the development and introduction of CAs ensuring that possible technical problems or restrictions are not overlooked. The interviews with the hospital employees were conducted via telephone, the computer scientists were consulted in face-to-face sessions and took place at their workplaces. All interviews took between 35 and 50 min and were recorded, analyzed, and, respecting data privacy protection, deleted once the evaluation was finished.

We developed a guideline following a consistent and systematic manner (Qu and Dumay 2011) with the following

contents: 1) introduction and summary of the purpose of this research; 2) self-introduction of the expert; 3) applications of CAs in general and in hospitals; 4) application of CAs in hospitals to enhance collaboration and team-building including advantages, disadvantages, and challenges; and 5) conclusion of the interview (possibility for further questions or closing remarks). We analyzed the data according to theoretically aspects for a structured description of the collected information (Mayring 2014). The material is generalized and reduced during an abstraction process. Within the deductive procedure, the resulting categorical system of the extensive prior knowledge is structured and integrated into the major challenges (Mayring 2015). The findings were then integrated into the categories and supported by important aspects from the extant literature. Already gained insights can thus be underlined by important aspects of the analysis. The interview guideline as well as characteristics of the interviewees can be found in the appendix (Table 4 and 6).

## Findings

### Overview

The execution of SLR resulted in 44 relevant articles (31 via initial, 8 via backward and 5 via forward search). The classification illustrates the assignment of each relevant article to the theoretical foundations (cf. Table 1). The number of search results per scientific database is depicted in the appendix (Table 7).

In the following, we are summarizing the most relevant findings of our SLR regarding the theoretical foundations and explain how collaborative issues are mitigated by CAs. We could not identify any prototype or implementation facilitating collaboration or team-building among employees in hospitals. Most existing CAs contain a visual component (e.g., Bickmore et al. 2010; Hayashi and Ono 2013; Traum et al. 2003) or a text-based input (e.g., Bickmore et al. 2005; Nezhad et al. 2017; Tegos et al. 2012). Roles and responsibilities are improved when CAs allow users to define roles (Tegos et al. 2012) and know who is responsible for which duty (Traum et al. 2003). Enhancing respect, trust, and communication is achieved by the diffusion of reports (Kretzer et al. 2015) or by providing communication channels appropriate for a given task (Seeber et al. 2018). Hierarchy, education, and liability are improved when CAs use sensors to determine if a person is too dominant in a conversation (Nakano and Fukuhara 2012), classify tasks according to their importance (Nezhad et al. 2017) and enable clinicians to focus on relevant tasks (Bickmore et al. 2010, 2011). To achieve goal setting, CAs provide a quick overview of prioritized goals (Nezhad et al. 2017; Preece et al. 2017) and assist in goal-driven communication (Bickmore et al. 2011; Kerly et al. 2007). Regarding interpersonal relations, CAs distinguish between socio-emotional and task-related interactions (Prada and

Paiva 2009). Problem solving is achieved when CAs understand the overall goals, know how to reach them (Traum et al. 2003), assist with task fulfillment by providing the most suitable information (Preece et al. 2017), and help to overcome barriers (Bickmore et al. 2011). Role clarification is reached when CAs are aware of the different roles within a team (Tegos et al. 2012) and who is responsible for which duty (Traum et al. 2003).

CAs are beneficial for overcoming the collaborative issues experienced by clinicians. Communication is tailored to the individual characteristics and demands of each team member (Seeber et al. 2018), fostering willingness to collaborate and promoting information disclosure (Fitriani et al. 2015; Shamekhi et al. 2018). CAs use various interaction styles like verbal and nonverbal communication or phrases and metaphors (Lim et al. 2011). Opaque responsibilities are tackled by CAs via sharing knowledge about clinicians' responsibilities and transparently express medical competencies (Hanna and Richards 2014; Nabeth et al. 2003). Additionally, CAs acquire information about responsible clinicians faster than humans because they can effortlessly handle large amounts of data while quickly adapting to changing demands (Preece et al. 2017). CAs simplify highly complex hospital infrastructures (Briggs et al. 2010) by fostering the presentation of information and linking disciplines enhancing information dissemination (Kerly et al. 2007; Seeber 2019). CAs combine knowledge from multiple sources and provide guidance on procedures and duties (Briggs et al. 2013; Seeber 2019). CAs enhance medical decisions as systems understand users' environments and evaluate patient data objectively, without any prejudices, while considering all medical information available (Bickmore et al. 2011; Siddike and Kohda 2018). With CAs, clinicians assess multidimensional situations and information that otherwise might be overlooked (Nezhad et al. 2017; Siddike et al. 2018). Furthermore, clinicians learn through agent-derived decisions as they receive adaptable feedback, fostering future decision-making (Nezhad et al. 2017) thus enhancing cognitive capabilities by raising awareness of options or pointing out specific patterns (Siddike et al. 2018).

## Major challenges

### Audience and interdependency

The notion of audience describes that CAs are used by multiple target groups. Hospital employees are not in the same age groups, differ in their expertise, have various professions, and work in different hierarchical structures and branches (Finlayson and Raymond 2012; Schadewaldt et al. 2014). One expert stated that "the age gap between some colleagues is simply extremely high. There are resident doctors who are in their mid-twenties and nurses who are in their late fifties" (E4). It is particularly relevant for hospitals to consider privileges in advance. For example, it needs to be validated if

**Table 1** Identified articles assigned to theoretical foundations 1) roles and responsibilities; 2) respect, trust, and communication; 3) hierarchy, education, and liability; 4) organizational processes; 5) medical treatment process; 6) goal setting; 7) interpersonal relations; 8) problem solving; and 9) role clarification

Database	Article	Collaboration					Team-building			
		1)	2)	3)	4)	5)	6)	7)	8)	9)
ACM	(Allen et al. 2002)					X			X	
BS	(Bersot et al. 1998)							X		
SD	(Bickmore and Giorgino 2006)				X					
SD	(Bickmore et al. 2005)					X	X	X		
SD	(Bickmore et al. 2010)	X		X						X
SD	(Bickmore et al. 2011)				X					
AISeL	(Bittner et al. 2019a)		X		X					X
BS	(Bittner et al. 2019b)			X						
BS	(Briggs et al. 2010)				X		X			
BS	(Briggs et al. 2013)				X					
FS	(Demetriadis et al. 2018)			X			X			
AISeL	(Elson et al. 2018)		X							
SD	(Fitriani et al. 2015)		X				X			
BS	(Gerhard et al. 2001)		X							
ACM	(Hanna and Richards 2014)		X						X	
IEEE	(Hayashi and Ono 2013)				X					
BS	(Just et al. 2005)				X					
SD	(Kerly et al. 2007)		X							
BS	(Lim et al. 2011)		X				X			X
AISeL	(Nabeth et al. 2003)	X			X					
ACM	(Nakano and Fukuhara 2012)			X						
ACM	(Nezhad et al. 2017)				X					
BS	(Ouldouali et al. 2017)						X			
SD	(Prada and Paiva 2009)		X	X						X
IEEE	(Preece et al. 2017)						X			X
FS	(Robb et al. 2015)						X			
FS	(Schmulian and Coetzee 2019)									X
SD	(Seeber 2019)				X					X
AISeL	(Seeber et al. 2018)	X	X			X	X			
ACM	(Shamekhi et al. 2018)								X	
AISeL	(Siddike and Kohda 2018)		X							
AISeL	(Siddike et al. 2018)									X
AISeL	(Stoekli et al. 2018)			X						
AISeL	(Tavanapour and Bittner 2018)									X
AISeL	(Tavanapour et al. 2019)									X
IEEE	(Tegos et al. 2012)					X				
FS	(Tegos and Demetriadis 2017)					X	X			X
IEEE	(Tegos et al. 2012)									X
SD	(Tegos et al. 2015)		X	X	X		X	X		
ACM	(Traum et al. 2003)	X		X						X
BS	(Winkler et al. 2019)		X	X		X				
ACM	(Xiao et al. 2019)							X	X	
FS	(Zumbach et al. 2005)							X	X	
Total numbers of articles		4	12	9	11	6	11	7	15	4

patient-related data is accessible by every team member or whether there must be a differentiation in the hierarchical

structures. CAs can adapt to existing hierarchy and responsibilities of hospital employees to improve collaboration.

Interdependency characterizes the coexistence of employees and CAs and communication channels being appropriate for a given task and target audience (Seeber et al. 2018). Equivalent research shows that understanding the demographic characteristics is a critical factor (Andrews 2001, 2002). However, interdependency may also lead to tasks being performed in isolation or clinicians blindly relying on results provided by CAs.

### Connectivity and embodiment

Connectivity and embodiment describe the interconnectedness of CAs and hospital departments and the preparation and presentation of patient-related data. Integrating different IS represents a main facet of supporting collaborative aspects (Kuziemyk et al. 2012). One expert emphasized that “information must be gathered from various data sources” (E6). A majority of IS applied in hospitals is tailored to the needs of each medical discipline and department with systems being highly customized. Not only departments but also IS are detached from each other (Lenz and Reichert 2007) but gaining shared understanding improves evaluation (Seeber 2019). CAs foster connection and sharing information (Marwan et al. 2016; Paul et al. 2016) by linking different systems and disciplines (Kerly et al. 2007) and assist with the documentation of the medical treatment process (Kerly et al. 2007). CAs also exist in different forms and can be utilized across a broad spectrum of situations. For example, CAs as text-based systems might be used in the outpatient clinic as hospital employees already use other systems with haptic input. Speech-based CAs could be applied within operating theatres as the sterile surrounding prohibits written input. The information presented by CAs can thus be oriented toward the patient, the disease and method of treatment.

### Trust and transparency

Trust is a major challenge for technology to be accepted and utilized (Frick et al. 2020; Siddike and Kohda 2018; Söllner et al. 2016) and must be considered from two perspectives in this research: trust in the CA itself and trust in other humans. Trust in technology is vital for its usage but more difficult to achieve as it does not provide a human-to-human relationship (Lankton et al. 2015). Especially the initial trust, which is also established by the perceived level of competence (Seeber et al. 2018), determines future utilization (McKnight et al. 2002; Söllner et al. 2016). Trust in CAs is particularly relevant as decisions proposed by the system might have an impact on collaborative processes and the treatment of patients. There might be differences regarding the type of CAs further influenced by selected collaborators and their individual characteristics. Transparency causes discomfort but is crucial for building trust (Wunderlich and Paluch 2017). One expert

underscored that “the application of such systems immediately makes information transparent, whereby errors in the treatment process become visible” (E6). This could lead to clinicians being less willing to disclose information to CAs which may even worsen collaboration. In hospitals, trust and transparency are particularly crucial as CAs do not only aid regarding the well-being of patients but disclose the entire diagnostic and treatment process to involved clinicians.

### Security, privacy, and ethics

Security as subjective perception characterizes data authentication and authorization (Pavlou 2001), which includes the risk of violating users’ (Yang et al. 2016) and patients’ privacy. Security is necessary for adopting and utilizing CAs (Han and Yang 2018), influencing trusting beliefs (Eastlick et al. 2006; Kim 2008) and the willingness to share information (Dhami et al. 2013; Dinev and Hart 2006). Privacy is a subjective anticipation as well (Pavlou 2001). Using information discriminately leads discontinued use of systems (Culnan and Armstrong 1999). Violations are, for example, unauthorized collection or secondary use of information, improper access and errors in personal information (Smith et al. 1996). One interviewee clarified that “it is not only about patient information but about personal data of employees” (E5). Both security and privacy are urgent aspects when storing personal data of individuals (Abdelhamid et al. 2015; Kuckein et al. 2010). Due to the unique characteristics of CAs, humans might tend to share more personal information and sensitive data compared to other technologies. Any data leaks creating benefits for enterprises, for example, insurance companies predicting hospital costs based on disease patterns, resulting in disadvantages for patients, should be eliminated. Furthermore, CAs raise ethical concerns related to the application of technologies in hospitals (Bickmore et al. 2010), especially considering the collected information (Derrick et al. 2011). When comparing CAs to IS, the perception around ethical and moral issues varies (Bendel et al. 2021; Siau and Wang 2018b). Since the development of CAs is enabled by AI, results are not always comprehensible to humans (Hagras 2018). Dubious recommendations by CAs, e.g., requesting additional consultation from another clinical department for a patient belonging to certain ethnic group, may not be recognized.

### Future research agenda for IS

Based on the findings from the SLR, enlightened by the semi-structured expert interviews, the following research agenda points out which research needs to be pursued to successfully establish CAs in clinical environments affecting the quality of care process. Table 2 summarizes future research questions when applying CAs for collaboration and team-building in hospitals.

**Table 2** Future research questions for identified challenges

Major challenge	Example research questions	References
Audience and Interdependency	<p>How can CAs involve and coordinate different healthcare professionals from multiple clinical departments? How do CAs deal with various norms or specifications with heterogeneous roles in hospitals?</p> <p>How does the deployment of CAs in hospitals influence the existing responsibilities and hierarchy of healthcare professionals during collaboration? Which tasks can be carried out by CAs for the different hospital areas to improve collaboration within the medical treatment processes?</p> <p>To what extent are CAs capable of promoting collaborative decision making with other clinicians in hospitals? In what ways do CAs help to ensure that health-related tasks are not performed in isolation?</p> <p>How can it be ensured that doctors or nurses do not blindly rely on results derived by CAs for the collaborative treatment of patients? How do physicians take responsibility for activities and decisions proposed by CAs within collaborative processes? Who is accountable for decisions given by CAs to clinicians in hospitals?</p>	(Bersot et al. 1998; Bickmore et al. 2005, 2010; Gerhard et al. 2001; Lim et al. 2011; Nabeth et al. 2003; Nezhad et al. 2017; Preece et al. 2017; Seeber et al. 2018; Shamekhi et al. 2018; Tegos et al. 2015, 2012)
Connectivity and Embodiment	<p>How can CAs connect historically grown patient data and systems that are already in use within hospitals, including their diverse infrastructures, to drive collaborative decisions?</p> <p>What medical information is captured through CAs? Which information must be exchanged with other hospital IS (e.g., electronic health records) to ensure flawless collaboration?</p> <p>How can relevant medical information be identified for different collaborators (e.g., hospital departments or clinical teams)? Which information must be presented to healthcare specialists to align with the patient's medical treatment and drive collaboration?</p> <p>What requirements must be placed on CAs to ensure their proper functionality fostering collaboration in any hospital environment, especially in sterile hygienic surroundings? How can different types of CAs, e.g., text-based or speech-based, be deployed for the varying hospital areas?</p>	(Briggs et al. 2010; Elson et al. 2018; Prada and Paiva 2009; Seeber et al. 2018; Siddike et al. 2018; Tavanapour and Bittner 2018)
Trust and Transparency	<p>How are employees convinced of the objectives and advantages of CAs to enhance collaboration in an environment where the well-being of the patient is the primary concern?</p> <p>Which collaboration team (e.g., hospital department or discipline) shall use CAs initially? Where can CAs be introduced to enhance collaboration without disrupting hospital procedures and patient treatment?</p> <p>How do collaborators cope with the transparency of their working behavior initiated by CAs? To what extent are clinicians willing to disclose information about working behaviors to CAs and other hospital employees?</p> <p>To what extent do clinicians perceive losing one's unique value or their individual knowledge and control when CAs are applied for collaborative purposes?</p>	(Allen et al. 2002; Bittner et al., 2019a; Hayashi 2018; Kerly et al. 2007; Nabeth et al. 2003)
Security, Privacy, and Ethics	<p>How can it be ensured that the data of patients as well as of hospital collaborators are not retrieved by third parties? How can an authorization concept for different healthcare collaborators for the use of CAs be established?</p> <p>To what extent are CAs able to determine objective characteristics of patients? What medical basis is used to generate recommendations to assist collaboration? How can disadvantages for patients (e.g., as part of a certain group or meet certain criteria) be excluded?</p> <p>How can CAs learn from decisions made by healthcare professionals? How can medical conclusions be generalized and transferred to other collaborative settings in hospitals?</p> <p>How can bias within the collaboration with CAs be recognized and resolved by hospital employees? What could a control mechanism by healthcare specialists look like?</p>	(Bickmore et al. 2010; Just et al. 2005)

**Audience and interdependency** Technology needs to be understandable and usable to fulfill the user's needs (Lim et al. 2011; Norman 2013). Various interaction possibilities need to

be offered to exploit the full potential (e.g., Bersot et al. 1998; Lim et al. 2011; Shamekhi et al. 2018). One participant pointed out that "older people prefer talking over typing" (E3).

Systems must be able to adjust to users' different needs, personalities, attitudes, and moods (Andrews 2001, 2002; Seeber et al. 2018) but also consider the responsibilities and hierarchy of clinicians. CAs must be interesting, demanding and stimulating while encouraging employees to think for themselves (Nabeth et al. 2003). One expert mentioned that "the decisions of these systems should be questioned by employees" (E3). Systems should actively support individuals and perform repetitive tasks for which no cognitive abilities are needed (Nabeth et al. 2003). Since decision making in isolation frequently yields inferior results (Driscoll et al. 2015), CAs need to promote collaborative judgments with other clinicians avoiding decisions being performed in detachment. Establishing a relationship and tailoring the CA's behavior to the needs of the user is essential. However, this may lead to users becoming dependent. One respondent emphasized that this, "conveys a feeling of false security" (E2). This represents social loafing behavior, where a user in a group attempts less effort to achieve a goal than when working alone (Karau and Williams 1993). CAs completing almost every task might result in employees no longer identifying themselves with a decision and not questioning or taking responsibility for it. Individuals might even forget essential information as cognitive skills are becoming superfluous. One expert even had the idea that "critical decisions may be highlighted or need to be confirmed by a third person" (E1). Decisions in clinical environments need to be questioned and verified as diseases vary and evolve over time (Eigner et al. 2019; Zwaan and Singh 2015). Overall, we derived the following research proposition (RP):

**RP1:** We propose more research on how CAs enhance collaboration in hospitals by converging different user groups in varying clinical environments due to multiple professions, hierarchical structures, and expertise levels. CAs promote collaborative decision-making for diverse employees and their demographics, while rigorously monitoring inputs on treatment decisions. Furthermore, accountabilities and responsibilities of employees for using decisions proposed by CAs influence the performance of the collaborative diagnostic and therapeutic process.

**Connectivity and embodiment** Due to the diversity of IS in hospitals, data must be extracted and processed from multiple sources. Information is not always captured digitally, patient data is still recorded in handwritten files, making it difficult to gather information quickly. One expert complained that "handwritten files are sometimes simply not readable. If the nursing staff is handing over the files to the next shift, they are not where I expect them to be" (E1). Digital information is entered across multiple systems and users must switch

between multiple applications (Lenz and Reichert 2007; Miner et al. 2016). The prerequisite of the treatment process being documented digitally (Kerly et al. 2007) ensures reaching the full potential of CAs. One expert underscored that "pendulum files will be dropped. We won't need in-house mail anymore. All information of a patient is visible for every colleague" (E1). With the introduction of CAs, systems shall be linked with each other and information is only accessible via the CA (Kerly et al. 2007). However, information from systems of every department must be merged by CAs to help in locating information effectively (de Moraes Batista et al. 2009; Kassner et al. 2017; Xu and Topi 2017). It is not only relevant to process information from the applying hospital but also to have access to the entire course of the patient's illness, including information from other healthcare facilities. One expert explained that "something like a digital medical record must contain all of the patient's information" (E5). Furthermore, technical communication between multiple systems must be ensured using unified protocols and interfaces. The information presented by CAs should always be comprehensibly and oriented toward the patient and the disease as well as the method of treatment (Nabeth et al. 2003). It should also be noted that different departments need deviant information. To avoid confusing determination and presentation, CAs must possess both sufficient medical vocabulary and necessary information about a given task (Bittner et al. 2019a) and choose a suitable method of communication (Hayashi and Ono 2013). Furthermore, CAs must adapt to different environments. One expert described different interaction modes and surroundings: "there are areas in which a doctor is sterile and where a smartphone cannot be used" (E5). This led to our second proposition:

**RP2:** We propose more research on how CAs interconnect different hospital employees, departments, disciplines, and existing clinical information systems to expedite the collaboration among involved stakeholders and enhance medical data retrieval. CAs adapt to different clinicians and diverse clinical environments where medical data is tailored to each patient's treatment process to foster flawless collaboration.

**Trust and transparency** Users tend to have prejudices when starting to interact with technology (Sheridan and Hennessy 1984). One expert underscored, "in the beginning, there will be anxiety and fear of extra work or even disinterest" (E4). Without building trust in CAs, support with cognitive tasks is not provided thus decision making becomes more difficult (Briggs et al. 2010; Elson et al. 2018). Users having trust in CAs are more likely to be supported when making decisions (Frick et al. 2019; Elson et al. 2018). Interpersonal relations are unavoidable as they involve trust in other humans (Amos

et al. 2005; Salas et al. 1999). The more physicians have trust in their colleagues, the more they acknowledge their expertise (McInnes et al. 2015; Schadewaldt et al. 2014). Trust in each other and the work affects the treatment process (McInnes et al. 2015; Schadewaldt et al. 2013, 2014). Lack of trust leads to clinicians questioning recommendations delays processes degrading collaboration (Briggs et al. 2010; Elson et al. 2018). To establish trust in CAs immediately, the intentions, benefits and possible obstacles should be explained and employees must be supported during the initiation process especially because users may have different experiences and previous knowledge (Frick et al. 2021). CAs should always have a detailed explanation on the focus of the task (Tavanapour and Bittner 2018). A step-by-step introduction is conceivable, not across all departments, but initially in one department or team, to identify potential errors and achieve a fully tested system. Utilization might be offered on a voluntary basis to recruit employees motivating or influencing their colleagues. One expert recommends introducing CAs “in an area where everyday tasks are executed that do not affect patients and where the speed is irrelevant” (E5). The application of CAs will increase the transparency of employees’ roles and their tasks. One expert explained that “today, I have to make a call and beg for an appointment - and then the blame is always on others” (E1). Transparency causes discomfort but is crucial for trust-building (Wunderlich and Paluch 2017). The new transparency of both information and employees who use CAs could lead to a feeling of being monitored, losing one’s unique value and knowledge. Not having trust yields in refusing or boycotting the system and hinders the willingness to disclose information. One interviewee mentioned that “transparency enables CAs to detect failures in the treatment process” (E6). However, alleviating related negative consequences is achieved when “good results and fast performances are communicated, rewarded, and made visible to other employees” and further “through the transparency of good work, a new team spirit can be created” (E3). This led to our third research proposition:

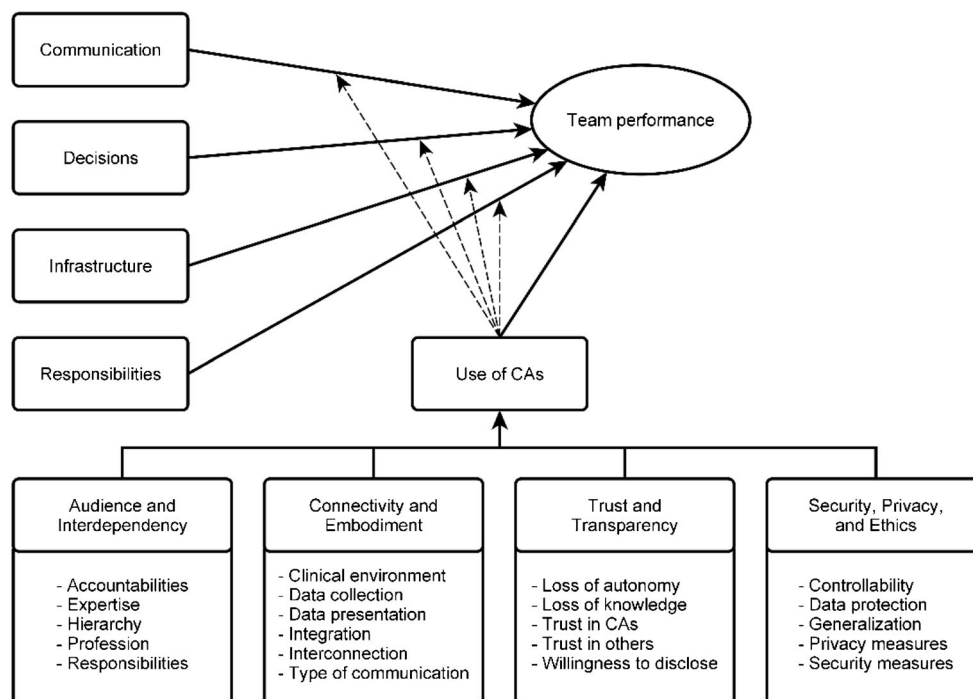
**RP3:** We propose more research on how CAs assist in building clinicians’ trust in other hospital employees and their abilities across interdepartmental boundaries, as well as in the technology itself, to generate advantages that will directly and indirectly affect clinicians and patients. CAs initiate transparency between collaborators, including their working behaviors and newfound clarity in the therapeutic process. Resistance factors, loss of autonomy, and the importance of individual knowledge when using CAs affect willingness to disclose information about medical decisions.

**Security, privacy, and ethics** There shouldn’t be any misuse by third parties and no information published without the consent of the person concerned (Just et al. 2005). This applies to the personal information of patients and employees. One interviewee summed up “the protection of data must be guaranteed at all times. There is sensitive information such as disease pictures or life expectancy” (E2). Information must be carefully protected with the highest security standards. Any data leaks or the disclosure of information without the consent of involved individuals might have serious consequences. There are also moral issues related to the application of CAs (Bickmore et al. 2010) as they are still being trained by humans and might contain unintended bias (Rothenberger et al. 2019; Siau and Wang 2018a) or even aim at changing the user’s behavior (Bickmore et al. 2010) and initial perceptions (Elson et al. 2018). One expert explained that “such a system must not make unethical or morally reprehensible decisions” and delineated “an example would be to remove a patient from a planned operation based on false, incomplete, or purely objective information” (E1). Based on decisions derived by physicians, CAs might learn prejudices. Even though this may be evident from the data, it is questionable whether this should lead to disadvantages for patients belonging to a certain group or meeting particular criteria. CAs objectively evaluate the patient’s condition but cannot obtain subjective impressions. When making difficult choices, a physician is ultimately responsible for the decision and must be aware of moral and ethical implications (Seymour et al. 2018). Decisions shall therefore be able to be overwritten and CAs need to learn and apply new knowledge to other circumstances. The above aspects lead to our final proposition:

**RP4:** We propose more research on how CAs ensure secure data collection, information presentation by clinicians, and storage of patients’ medical data, addressing how unauthorized access is prevented. Furthermore, we demand determining the extent to which morally and ethically unacceptable results are identified by clinicians and CAs to avoid potential safety hazards for patients and what a control mechanism could look like. CAs and hospital collaborators learn from decisions and medical conclusions to generalize and adapt to other collaborative settings in clinical environments.

Drawing from the major challenges identified when applying CAs for collaboration and team-building in hospitals, and combining these with our propositions for future in-depth research, we designed our final research model (cf. Fig. 2). We argue that the major challenges, including their various factors, directly impact the extent to which CAs are used in hospitals. Future research should not only consider the individual research questions as outlined in the agenda, but also

Fig. 2 Final research model



examine the individual influencing factors of each major challenge and their relationships, which impact the use of CAs for enhancing team performance in hospitals.

Finally, it should be noted that these challenges also influence each other; for example, unethical decisions or the type of CA inevitably influences trust in the system. The results presented above show that there are several questions that must be tackled in future research. However, this research advocates that CAs as a subset of hybrid intelligence are capable of improving collaboration and team-building, and thus, the quality of healthcare services and team performance in hospitals.

## Conclusion and limitations

Drawing from the literature about collaboration and team-building, enlightened by expert interviews, this article contributes to theoretical foundations by presenting challenges that need to be faced when applying CAs in hospitals and pointing out areas where future in-depth investigations are needed. We answer our research question by demonstrating how the interaction between humans and CAs affects the quality of care process and which factors impact the use of CAs for enhancing team performance. The conclusions are relevant for researchers as the overview of challenges is helpful in considering difficulties before the actual introduction of

CAs. Practitioners understand the extent to which CAs improve collaboration and team-building in hospitals.

This research is not free of limitations. There are various notations for the term CAs that are used interchangeably in research and practice. However, to narrow down the scope of this study, we linked the most common terms within the SLR. Even though the identified articles provide a sufficient foundation for the research agenda, we may have missed the retrieval of relevant literature providing additional findings. We further present a small group of experts who cover a limited fraction of knowledge. Although we conducted interviews with both physicians and computer scientists, further stakeholders should be considered in future research to retrieve a broader picture, i.e., other hospital employees such as nursing staff or surgical assistants or computer scientists working in the healthcare sector.

Besides the research agenda, studies should also focus on deviant perspectives. What further challenges need to be considered when CAs are applied in hospitals? What other benefits besides collaboration and team-building can be achieved? How must a system be designed to be effective and efficient and to adapt to different users in hospitals? Our future research aims at identifying exact use cases where systems can be used to improve collaboration and team-building in hospitals. Therefore, we are going to observe different clinicians in several hospitals over a longer period to grasp the phenomenon of how CAs concretely support collaboration.

## Appendix

### Collaborative challenges in hospitals

**Table 3** Challenges and potential for CAs improving collaboration in hospitals

Challenges in hospital	Potential for CAs	Example references
Communication among clinicians (e.g., miscommunication for medical dispensing).	Communicative support (e.g., among different hierarchical structures or disciplines) Performance improvements in diagnostic and therapeutic process Stress-free work environment	(Balogh et al. 2015; Kanjanarat et al. 2003; Kripalani et al. 2007; McInnes et al. 2015; Schadewaldt et al. 2013, 2014)
Responsibilities of clinicians as patients are treated by multiple specialists with different medical information.	Enhancing team atmosphere and cohesion Transparent information on clinicians' duties Fast retrieval of responsible healthcare specialists Simplified goal-driven communication and collaboration	(Bickmore et al. 2011; Kerly et al. 2007; Rosen et al. 2018; Traum et al. 2003; Wears and Berg 2005)
Infrastructure as multiple systems for various purposes exist, containing different information; interconnected and operated by various users.	Providing suitable information for users Merging data from multiple origins Fast retrieval of medical information Minimizing task duration Simplified reporting of information	(Angst et al. 2010; Hanseth and Bygstad 2015; Meier et al. 2014; Nasirian et al. 2017; Preece et al. 2017)
Decisions are depending on individual experiences, emotions and mental state of clinicians.	Transparent diagnostic and treatment process Objective and equal evaluation of patient data Non-prejudices decisions (e.g., objective conclusion based on medical facts) Independent decisions regardless of time or mental state	(Chang and Hsu 2009; Gnewuch et al. 2017; Laurenzi et al. 2017; Seeber et al. 2019; Singh et al. 2020)

### Interview guideline

**Table 4** Interview guideline (German interview questions have been translated into English)

Phase	Research goal	Questions
Introduction	Welcoming the interviewee and providing general information about the research and brief introduction to the topic.	–
Demographic data	Getting an understanding of the interviewee including position within the hospital/organization and the areas of responsibility.	a) Could you please introduce yourself? b) What is your current position in your hospital/organizations and what are your responsibilities?
Application of CAs	Awareness of previous experiences with CAs and applications within in general and in hospitals.	a) What do you associate with the term “Conversational Agent” and which application areas are you familiar with? b) Which areas of application are known to you in hospitals? Afterwards the researchers provide an explanation of CAs and current examples to assume the same knowledge among all participants.
CAs in context of collaboration and team-building	Possible applications of CAs in hospitals, especially regarding to collaboration and team-building considering the theoretical foundations.	a) Can you imagine how CAs can be applied to improve collaboration and team-building in hospitals? b) What might be the advantages and disadvantages when introducing CAs? c) How important is the understanding of the role and responsibilities for you and your colleagues? (roles and responsibilities) d) What role does respect, trust and communication play, especially with colleagues? (respect, trust and communication) e) How important is the hierarchy and education of hospital employees? (hierarchy, education and liability) f) How can the organizational process or the medical treatment of patients be affected? (organizational processes and medical treatment process) g) How can the achievement of goals and problem solving be supported? (goal settings and problem solving) h) How important are interpersonal relations and the understanding of one's own role? (interpersonal relations and role clarification)
Finish	Debriefing of the interviewee and explanation of the research background.	–

## Exemplary Assignments

**Table 5** Example statements and exemplary assignment to a category

	Category	Sample statement
Collaboration	1) roles and responsibilities	“the role of the system is primarily to provide information to enable the user to make informed choices” (T. W. Bickmore et al. 2010, p. 280)
	2) respect, trust, and communication	“After having defined different interaction modalities for communication with the Sprytes, we took into account the right assignment of the modalities to the different users in order to increase their engagement as well as collaboration.” (Lim et al. 2011, p. 227)
	3) hierarchy, education, and liability	“Teamwork in STEAM is based on the agents’ building up a hierarchy of joint intentions and monitoring other members’ and team’s performances and reorganizing the hierarchy when necessary” (Prada and Paiva 2009, p. 82)
	4) organizational processes	“Indeed, what the users ultimately need are not so much tools that will be able to process more efficiently an even larger amount of information, but rather ‘smarter’ tools that are able to support more effectively the knowledge related processes that are inherently connected to their work, and the operations of organizations.” (Nabeth et al. 2003, p. 70)
	5) medical treatment process	“These examples are motivated by interactions we have observed in a medical advisor domain in which the system acts to help a person manage their medications.” (Allen et al. 2002, p. 778)
Team-building	6) goal setting	“The working alliance has three sub-components: a goal component, reflecting the degree to which the helper and client agree on the goals of the therapy” (T. Bickmore et al. 2005, p. 22)
	7) interpersonal relations	“This initial evaluation of a relational agent in a health behavior change intervention indicates that patients are generally receptive to the technology and respond in ways analogous to how we would expect them to respond when the same emotional and relational communication behaviors are used by human health providers.” (T. Bickmore et al. 2005, p. 28)
	8) problem solving	“Our approach to the later stages of change involves long-term and short-term goal setting negotiation, positive reinforcement when goals are met and ‘problem solving’ to overcome barriers when goals are not met.” (T. Bickmore et al. 2011, p. 189)
	9) role clarification	“Agents can be given different personalities and different roles (e.g. tutor, coach, learning companion or opponent), which may increase the interest of the students.” (Tegos et al. 2011, p. 162)

## Experts' characteristics

**Table 6** Characteristics of the interviewees

#	Gender	Age	Tenure (years)	Position	Specialty	Discipline	Hospital
E1	Female	30	1	Resident doctor	Surgeon	Cranio-maxillofacial surgery	University Hospital of Duesseldorf
E2	Female	30	3	Resident doctor	Gynecologist	Obstetric care	University Hospital of Frankfurt
E3	Male	34	5	Attending physician	Rheumatologist	Rheumatology	University Hospital of Munich
E4	Male	65	30	Chief physician	Anesthetist	Anesthesia	Saint Francis Hospital Muenster
#	Gender	Age	Tenure (years)	Position	Branch		
E5	Male	28	8	Full Stack Developer	IT Management and Consulting		
E6	Male	32	10	Head of Data Analytics	IT Service Provider		

## Search results

**Table 7** Number of search results per scientific database (articles up until October 2019)

Database	No. of results	No. of relevant results
ACM (Association for Computing Machinery)	173	7
AISel (Association for Information Systems Electronic Library)	140	10
IEEE (Institute of Electrical and Electronics Engineers)	42	4
JSTOR (Journal Storage)	55	0
SD (ScienceDirect)	399	10
Backward search	18	8
Forward search	14	5
Total numbers of articles	841	44

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