Covid-19 as an Incubator Leading to Telemedicine Usage: KM Success Factors in Healthcare

Florian Neft
University of Hagen
florian.neft@fernuni-hagen.de

Karolin Eva Kappler
Catholic University of Applied Science
k.kappler@katho-nrw.de

Stefan Smolnik
University of Hagen
stefan.smolnik@fernuni-hagen.de

Abstract

Virtual hospitals offer a platform for healthcare workers to share knowledge, treat patients equally everywhere and, thus, reduce patient mortality rates. Such platforms include different technologies, for example telemedical applications. The use of these technologies and the need to get specific knowledge on the patients' treatment was reinforced in the past years due by Covid-19. Not only the treatment of Covid-19, but also that of other diseases can be improved by increased technology use. By incorporating the KM success model, we will identify KM success factors leading to the use of virtual hospitals. This research observes the KM success model in the context of the low-digitalized field of healthcare. Consequently, we evaluate how the existing KM success model needs to be adjusted according to the peculiarities of healthcare.

Keywords: Covid-19, healthcare, knowledge management, KM success factors, telemedicine.

1. Introduction

The global Covid-19 outbreak changed people's lives and their readiness to use technologies (Naeem et al., 2022). This change can not only be observed in various areas of daily life, but also in healthcare (Bokolo, 2021; Peine et al., 2020). The willingness to share information and knowledge has significantly increased (Naeem et al., 2022). This reflects the emerged opportunities for knowledge management (KM) in healthcare (Naeem et al., 2022).

Until the occurrence of the first Covid-19 cases, Covid-19 was an unknown disease (Bokolo, 2021). In the beginning, physicians had to observe, for example symptoms, clinical trials, and medication therapies (Sitammagari et al., 2021). Literature was quickly published, leading to a larger knowledge base of the new disease. The rapid, worldwide communicability of Covid-19 increased the need to share knowledge inter-organizationally to treat patients equally everywhere (Bokolo, 2021).

To cope with this need, governments established virtual hospitals and physicians used various technologies (Bokolo, 2021; Sitammagari et al., 2021). Some physicians called others within their network and asked for an assessment via phone. Other physicians applied videoconferencing tools to exchange information with a colleague via camera or to show the patient's health status via a dashboard (Bokolo, 2021; Guinemer et al., 2020). These scenarios present some examples of the use of different telemedical applications in virtual hospitals, and similarly show the intensified physicians' intent to use technology (Sitammagari et al., 2021).

These two developments, namely the increased need to share knowledge and the physicians' intent to use technology, make it relevant to analyze KM and its success factors in health information systems (IS). Recently, the number of health IS papers, which deal with the implementation, and use of IS is rising (Baird et al., 2020; Chen et al., 2019). In contrast, according to Chen et al. (2019), less than 6% of all health IS papers published between 2004 and 2017 were classified as dealing with KM in healthcare. When narrowing down the topic further to hospitals, we see that only a few papers combine KM and hospitals (Karamat et al., 2019). However, the latest research in public health shows sustained knowledge sharing as a trend (Naeem et al., 2022).

The late adoption of KM in hospitals can be attributed to many challenges, such as multiple stakeholders, scarce technological resources, and the fragmented, highly specialized nature of medical knowledge (Karamat et al., 2019; Nicolini et al., 2008). These characteristics lead to an uncertainty of KM success in hospitals and focus relevance on analyzing and integrating those factors which lead to IS usage and KM success (Karamat et al., 2019).

This research is further motivated by increasing technological possibilities. KM emerged in the 1990s, mainly in the field of IS (Alavi & Leidner, 2001). Between 1999 and 2003, KM was frequently studied, whereas healthcare was one of the emerging topics in IS research between 2014 and 2018 (Chen et al.,

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2019). Since then, new technologies, such as robotics and machine learning, emerged, which can improve hospital processes (Jennex, 2017). The lagging KM in hospitals, combined with the increasing technological possibilities, lead to the following research objective:

Identification of KM success factors leading to the use of virtual hospitals' digital platforms and knowledge sharing between the participating hospitals.

This paper focuses on the evaluation of virtual hospitals and their platforms offering telemedical services, which affect KM in participating hospitals. We observe how physicians apply the knowledge gained about Covid-19 and examine if this generates benefits in participating hospital wards. In this paper, we specify Jennex's (2017) KM success model for virtual hospitals based on a single case. Therefore, we evaluate Covid-19 teleconsultations within the pilot phase of a European virtual hospital, which is an ideal type due to its special features regarding KM.

This paper is a transdisciplinary approach combining healthcare peculiarities with KM. It explains health KM success factors leading to use of virtual hospitals and, thus, extends Jennex's (2017) KM success model by including medically relevant aspects, such as patients' singularity. The combination of the research areas KM and healthcare extends the research stream of KM success factors (Jennex, 2017, Kulkarni et al., 2007) and interorganizational service and knowledge delivery (Barrett et al., 2015) by integrating healthcare aspects (Lupton & Maslen, 2017; Marx et al., 2022). In this case, KM success means better physician performance, less patient transports, and a higher survival rate among the patients perceived by the common virtual discussion of a patient. Consequently, this study contributes to success and performance measures of KM.

2. Theoretical background

2.1. Virtual hospitals

In the past, multiple researchers used the term virtual hospital to list the use of technologies which enable hospitals to cooperate via the web (Sitammagari et al., 2021; Udeh et al., 2018). We follow the definition of Sitammagari et al. (2021), who describe a virtual hospital as an institution which monitors and remotely cares for an eligible patient on a hospital level via monitoring technologies. In this context, Udeh et al. (2018) mention tele-intensive care units (ICU) which provide critical care expertise 24/7.

These classifications imply the contribution of telemedical applications in virtual hospitals to the care process in various ways (Greenhalgh et al., 2020; Lupton & Maslen, 2017; Sitammagari et al., 2021; Udeh et al., 2018). By definition, telemedical applications fulfill four criteria: clinical support, no barriers in place and time, usage of information technology, benefit for patient (World Health Organization, 2010). Telemedical applications involve face-to-face consultations (teleconsultation), the monitoring of patients in homes and clinics, such as ICUs (telemonitoring) and the self-care of patients (Greenhalgh et al., 2020; Lupton & Maslen, 2017; Wilson & Maeder, 2015).

Physicians conduct teleconsultations via videoconferencing tools, which include cameras and mobile devices (Lupton & Maslen, 2017). For the telemonitoring, the integration of further sensory systems, such as digital stethoscopes, is required to remotely assess the patient (Lupton & Maslen, 2017). These applications are developed to different levels of maturity worldwide. Whereas in some countries, such as the USA, China, and several European countries, telemedicine has become a significant part of health care delivery, other countries have not yet adopted telemedicine, because of lagging technological infrastructure and slow data transmission rates (Lupton & Maslen, 2017; Wilson & Maeder, 2015).

To summarize, within this study, we regard a virtual hospital as a platform, which offers a telemedical application contributing to the hospital's care process. Besides the described technological aspects required for virtual hospitals, further KM factors exist, which lead to KM success.

2.2. KM success factors in healthcare

KM systems already have a high maturity level as several publications have dealt with IS implementation and adoption and, accordingly, KM success factors in diverse areas in the past (Alazmi & Zairi, 2003; Liu et al., 2005). Table 1 lists identified factors leading to KM use (Alazmi & Zairi, 2003).

Table 1. Factors leading to KM use.

Category	Factor	Reference
Techno-logical	Infrastructure	(Alazmi & Zairi, 2003)
	Transmission, inter-operability	(Armfield et al., 2014; Marx et al., 2022; Wilson & Maeder, 2015)
Know-ledge	Knowledge creation	(Agrawal & Mukti, 2020; Kulkarni et al., 2007)
	Knowledge transfer	(Jennex, 2017; Kulkarni et al., 2007)
	Knowledge infrastructure	(Alazmi & Zairi, 2003; Ha et al., 2016)
Organi-zational	Culture	(Davenport et al., 1998; Rodziewicz et al., 2022)

	Staff perception and attitude	(Weeger et al., 2021; Lapointe & Rivard, 2005; Greenhalgh et al., 2014)
	Management, Leadership	(Kulkarni et al., 2007; Liu et al., 2005)
External	State regulations	(Lupton & Maslen, 2017; Wang et al., 2021)
	Financial incentives	(Zanaboni & Wootton, 2012)

Table 1 contains references older than 2010 outlining KM success factors in general and showing a high maturity of KM (Alazmi & Zairi, 2003; Kulkarni et al., 2007; Liu et al., 2005). Moreover, Table 1 also lists contemporary healthcare references published within the last five years, which do not show an equal maturity level (Lupton & Maslen, 2017; Wang et al., 2021; Weeger et al., 2021). Literature on KM systems' implementation and adoption in healthcare has mainly focused on performance measures, for example, the increased efficiency, less transportation effort, and higher quality due to the use of virtual hospitals (Lupton & Maslen, 2017; Peine et al., 2020). Despite these benefits, virtual hospitals fail to deliver an equivalent outcome as a face-to-face treatment (Lupton & Maslen, 2017). Lapointe and Rivard (2005) indicate the functionality, usability, role, and the organizational culture as aspects leading to IS resistance. Weeger et al. (2021) also emphasize post-implementation issues, such as dysfunctional workflows and workers' resistance, which inhibits hospitals' goals like better care quality or efficiency (Strong et al., 2014). Some goals, such as hospitals' increased productivity and efficiency, partially contradict healthcare workers' focus, which is contributing to the patients' recovery (Sarker et al., 2019). This fragmented focus of healthcare and its different stakeholders distinguishes healthcare from other sectors and makes it a special field of action (Weeger et al., 2021). In this research, we will identify peculiarities of healthcare leading to the use of teleconsultations and, thus, KM within a virtual hospital. Therefore, we pose the research question:

Which specific aspects of healthcare lead to KM success within teleconsultations and the use of virtual hospitals' platforms?

Literature provides IS models which explain the acceptance (Davis, 1989; Fishbein & Ajzen, 2009), the use (DeLone & McLean, 2003) and the adoption (Tornatzky & Fleischer, 1990) of technologies. Researchers adjusted these models for the field of KM (Jennex, 2017; Kulkarni et al., 2007). We apply Jennex's (2017) KM success model, as we intend to identify cultural, technological, and external KM success factors. This model best incorporates these different factors, whereas Kulkarni et al.'s (2007) KM success model mainly focuses on the KM system and processes. Jennex's (2017) KM success model also includes these processes and contains the most important aspects of Table 1. Thus, we think Jennex's (2017) KM success model, shown in Figure 1, provides a holistic picture.

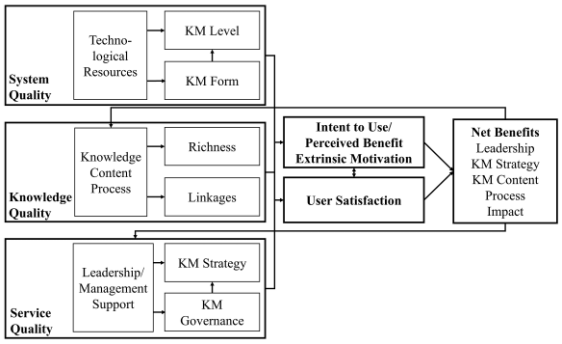

Figure 1. Jennex's (2017) KM success model.

Figure 1 depicts the separation of KM success factors into system quality, knowledge quality and service quality (Jennex, 2017). System quality describes the available technological resources (type of hardware, network, databases), the KM form (digitalization level of KM processes), and the affected KM level (KM functions such as search and retrieval) (Jennex, 2017). Knowledge quality consists of knowledge content process (organizational processes available to search, use and share knowledge), the richness (accuracy and timeliness of knowledge), and the linkages (listing of available expertise) (Jennex, 2017). The remaining factor, service quality, defines the management or leadership support, the KM strategy, and the KM governance (Jennex, 2017). The intent to use, and user satisfaction depend on how system, knowledge and service quality are fulfilled and incorporated in the specific KM model (Jennex, 2017).

Whereas some researchers regard intent to use strictly as intent, others also evaluate usage and do not strictly separate these two terms (DeLone & McLean, 2003; Liu et al., 2005; Petter et al., 2008). We conceive intent to use as a term including both use and intent to use (Petter et al., 2008). In case users are satisfied and intend to use a KM system, they receive net benefits (Jennex, 2017). These net benefits, furthermore, affect the knowledge and service quality (Jennex, 2017). In the following, we apply this KM success model to a virtual hospital and ask whether further connections and factors are required in healthcare.

3. Methodology

3.1. Research subject

To answer the research question, we conduct a single case study on a European virtual hospital. The observed virtual hospital offers teleconsultations between ICU physicians of teaching and community hospitals. In the first months of the Covid-19 pandemic, community hospital physicians had little experience of Covid-19, as teaching hospitals admitted most patients. Due to the increase in patient numbers, community hospital physicians also had to treat Covid-19 patients. If they required advice from the more experienced teaching hospital physicians, they requested a teleconsultation via the virtual hospital. Within the teleconsultation, the community hospital physician stated the patients' vital signs verbally or via camera first. Then, the teaching hospital physician asked further questions for clarification. The two ICU physicians shared their thoughts and treatment ideas. The teleconsultation ended with a proposal regarding the patient's further treatment path (Marx et al., 2022).

In the long term, the virtual hospital's goal is to establish a knowledge sharing network via the use of telemedicine and teleconsultations (Marx et al., 2022).

3.2. Data collection

We conducted a qualitative interview study with 22 participants of the virtual hospital.

Table 2. Details on the interviewed sample.

Role	Gender	Career level	Interview ID
Consultant	11 females, 6 males	11*level 1, 5*level 2, 1 pharmacist	1, 2, 3, 4, 6, 7, 8, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22
Enquirer	1 female, 4 males	2*level 2, 3*level 3	5, 9, 10, 11, 12
Legend: *Career level*: level 1 = fellow, level 2 = head physician of department, level 3 = attending physician			

Table 2 contains information about 22 interviewees, of whom 12 are female and ten are male. Twenty of the participating physicians have an additional qualification in anesthesiology, one is a pharmacist and another one is an infectiologist. The majority of the interviewees (17) participated as teleconsultants, and the remaining five interviewees as enquirers. According to their hierarchical level, eleven of the consultants are fellows, one is a pharmacist and five are head physicians of department, whereas three of the enquirers are attending physicians and two are head physicians of department. We interviewed more consultants, as they partially participated in previous telemedicine projects. They also conducted many teleconsultations within the virtual hospital and, thus, can assess technological settings and usage patterns.

To identify KM success factors, we asked the consultants and enquirers eleven equivalent questions. These questions covered the different factors in Jennex's (2017) KM success model, for example the KM process (e.g., How did you store the knowledge gained?, Did you forward the knowledge gained?), the technological resources (Was the technological infrastructure working well?), the user satisfaction (Has the transferred knowledge been helpful to you?), and the benefits (Have you changed your daily routines according to the proposal?).

We conducted all interviews with an average length of 25 minutes between October '21 and January '22. The participation rate among the teleconsultants is 42.5% (17 of 40 teleconsultants within two teaching hospitals), whereas the rate among the enquirers is significantly lower at 4.3% (4 out of 93 enquiring hospitals). This low participation rate from the enquirers is linked to the higher number of Covid-19 patients in the participating enquirers' hospitals within the interview execution timeline. We chose this timeline because of the approval of the two teaching hospitals' ethics committees in October '21.

3.3. Data analysis

To evaluate the participants' answers, we recorded all interviews and transcribed them. We then built a coding scheme containing 12 categories, based on the factors of Jennex's (2017) KM success model, for example know_richness, know_linkages, and know_content representing knowledge quality. We then identified a total of 86 codes by summarizing similar statements as shown in Table 3.

Table 3. Examples of the coding scheme.

Category	Code	Explanation	Statement
Know_ richness	Focus	Users liked the teleconsultant's focus (e.g., no other, parallel tasks)	"You (…) get someone who (…) has a very calm view. (ID21)"

We used Atlas.ti to code all statements. Two independent researchers executed the coding. The intercoder reliability is 0.751, which shows a high consensus between the two researchers. Afterward, we summarized similar codes by applying Mayring's (2014) concept of qualitative content analysis.

4. Results

The results are split into the factors of Jennex's (2017) KM success model to identify healthcare peculiarities within the KM system 'virtual hospital'.

4.1. System quality

System quality, the first factor of Jennex's (2017) KM success model, shows a broad range of applied technological resources. The enquirers and consultants used a homepage to align appointments, a videoconferencing tool to meet, and a digital patient file to document the proposal (ID2, ID3). The enquirers sometimes preferred to use a phone due to firewall restrictions in the community hospitals (ID22). One enquirer selects the phone for general questions and the videoconferencing tool for specific cases (ID11).

A consultant expressed the change of her behavior towards an increased usage of videoconferencing tools (ID21). She suspects a lower technological expertise among the enquirers as they typically choose the phone (ID21). Some enquirers, however, consulted via visiting carts containing a laptop and a camera to take the consultant to the patient's bed and show the patient (ID9). Others also shared patient data with the consultant via a patient data management system (ID10, ID11). Consequently, the bandwidth within the used technological resources shows broad differences among the participants. The enquirers partially explained the use of the phone because of regionally lacking technological infrastructure and low transmission rates. These aspects present a barrier to the intent to use the virtual hospital (e.g., ID9, ID12).

KM form is another factor within system quality. The consultants outlined their participation in jour-fixe meetings in which they shared and received the latest literature findings and clinical expertise:

"To ensure treatment quality (…), we had a meeting (…) every Tuesday, in which we shared the experience of the teleconsultations and received the impressions of the colleagues on the wards (ID13)."

Other KM forms are the use and update of patient data management systems, in which physicians regularly document relevant patient events (ID9, ID20). Furthermore, ICU physicians and specialized ones, for example internists, attend daily rounds:

"We do the round every morning with multiple physicians (…) and communicate procedures (ID10)."

The interviewees presented further ways to transfer knowledge, for example by chatting with a coworker (ID8). These chats helped quickly sharing the latest experiential knowledge (ID8). Besides these widely known KM forms within hospitals, the teleconsultations answer specific, single cases:

"This have been specific questions, for example the patient is respirated with these parameters- What can we do here? (ID22)"

Other hospitals used the teleconsultations to exchange ideas with the teaching hospital on a regular basis (ID8). These presented KM forms affect the available KM levels, such as search and find patient information in the digital patient file or look for latest treatment guidelines in the literature (ID6, ID22). Moreover, consultants created and offered learning videos for standard treatments, such as bringing a patient into abdominal positioning (ID15).

4.2. Knowledge quality

Besides these aspects affecting the system quality, the knowledge quality is influenced by another three factors: knowledge content processes, linkages, and richness. The physicians named different knowledge content processes, such as the creation of experiential knowledge of the Covid-19 treatment (ID1, ID16), the creation of knowledge by reading literature (ID1, ID20), the knowledge transfer by sharing recommendations, and the provision of patient-specific knowledge by giving an estimation (ID11, ID22). As the teaching hospitals' consultants treated Covid-19 patients first, they created experiential knowledge:

"Heinsberg was the first hotspot within the first wave (…). We treated and respirated many patients (…). By this, we have been able to acquire knowledge (…) and transferred it into guidelines (ID16)."

To be prepared for the teleconsultations, the consultants did not only rely on their own knowledge, but enriched it with further literature:

"There have been a lot of publications which influence the clinical routine (ID18)."

The consultants accessed the latest literature to avoid recommending outdated knowledge (ID22). This example implies the timeliness of the shared knowledge. The enquirers furthermore especially valued the consultants' practical recommendations on a specific patient (ID5, ID10, ID11). They not only highlighted the fast set-up of the virtual hospital, but also the quick support in case they required help (ID5). No matter the time, the enquirers could quickly request a teleconsultation:

"You can choose, if it is very urgent and should happen within 30 minutes or if it got some time and should happened within the next 4 hours (ID20)."

Furthermore, the richness of the transferred knowledge is emphasized. The consultants did not

have any emergency case in the background and fully focused on the external patient (ID21):

"I can include somebody who is external and has a calm view, who has no time pressure (ID21)."

The enquirers asked the consultants very specific questions and valued their diligence treating these requests (ID3). In complicated cases, the consultants collected extended information within their hospitals:

"In general, this are comorbidities or secondary diseases, for which (...) questions arise (ID10)."

The enquirers improved their therapy by getting responses to these complicated requests (ID9).

4.3. Service quality

The service quality, consisting of the factors leadership and management support, KM strategy and governance, is another criteria leading to KM success (Jennex, 2017). The teaching hospitals assigned physicians to the virtual hospital, which shows management support (ID20). In parallel, the enquirers often lacked time to use the teleconsultations:

"I think we still underutilized the teleconsultations because in some situations colleagues just didn't have the time (ID11)."

The consultants also outlined the physicians' time scarcity even before the Covid-19 outbreak (ID1). Another barrier to the use of the transferred knowledge is the hierarchical model within hospitals because local higher-level physicians can revise the proposal made during the teleconsultations (ID18).

Another factor is the KM strategy. The virtual hospital's goal is to provide expert knowledge without any restrictions of time or place (ID1, ID4). To fulfil this goal and use the virtual hospital's platform, enquirers should perceive incentives, such as learning a procedure, the correct drug dosage, or having experts, for example infectiologists, who do not work in the local hospital, easily available (ID9, ID12).

The KM governance also contributes to the service quality. The interviewees mentioned data security for videoconferencing software and the digital patient file (ID14). Both technological resources were created for each meeting and only accessible by the participating physicians (ID14). This leads to knowledge silos. Nevertheless, this strategy also ensures data security (ID14).

4.4. Intent to use, user satisfaction, and net benefits

System quality, knowledge quality and service quality further lead to user satisfaction and intent to use. The enquirers requested a teleconsultation in case their institution did not employ a specialized physician (ID1). Getting such an expert opinion can help community hospital physicians learning the treatment procedures for a critically ill patient (ID1, ID10, ID12) or doublechecking their opinion:

"I would request it (...) whenever (...) I am not sure or want a second opinion that this patient could possibly benefit from a technical procedure that only the teaching hospital knows (ID11)."

This statement shows the physicians' desire to evaluate whether the consultants propose any further treatment idea for a specific patient (ID11, ID12).

Moreover, the enquirers used teleconsultations to provide their fellows with insights into disciplines, which are handled in a more specialized way within the teaching hospital (ID11). Additionally, enquirers requested teleconsultations to help their fellows learning to present patients (ID9) or when they wished a regular patient checkup (ID12).

Another relevant factor influencing KM success is the user satisfaction within the virtual hospital. The interviewees emphasized the cooperation at eye level (ID17). The knowledge shared in the teleconsultation was clear, effective, and understandable (ID12). This implies the physicians' competence, as the participants knew the technical terms and did not experience any terminology barriers (ID17). By perceiving such competent support, users explained their trust in physicians in the virtual hospital (ID11, ID15). The users liked the KM system and expressed the importance of knowledge sharing (ID5). Another aspect affecting user satisfaction is the infrastructure used for the teleconsultations. The teleconsultations had low technological requirements and most physicians had no issues using the teleconsultations, which worked well, despite their outdated IT infrastructure (ID2, ID9, ID12, ID13, ID22). In exceptional cases, physicians aligned with their IT departments to make minor IT configurations (ID22).

These aspects, namely the intent to use and the user satisfaction, are fundamental to the net benefits, such as process adjustments, enhanced treatment quality, reduced number of patients in the teaching hospitals, and improved personal patient handling (ID8, ID22). The consultants observed an emerged adherence of the Covid-19 guideline among the enquirers (ID8). The knowledge base in the community hospitals increased substantially and the physicians recorded their own experiences (ID22). Their decision-making process accelerated by receiving a second opinion via teleconsultations, which positively affected the treatment quality (ID14). Furthermore, the virtual hospital's performance can be measured by a reduced number of patient transfer requests. This was confirmed by multiple physicians

and supports patient's affiliates (ID3, ID12). The main benefit is the improved survival rate (ID11):

"The consultations were always used to answer the question, do we continue to treat the patient at our hospital, or do we hand him over to the teaching hospital? (…) Twice a patient was transferred to the teaching hospital. Once a patient was even picked up from our hospital, put on ECMO and then transported (…), and all (…) these patients survived (ID11)."

This statement shows that knowledge sharing and use within the virtual hospital can be lifesaving to the discussed patients. These facts and benefits are outlined in medical publications, which observed the reduced mortality rate and length of stay of virtual hospital patients (Marx et al., 2022; Peine et al., 2020).

5. Discussion

The results lead to four findings which are specific to healthcare and require adjustment to Jennex's (2017) KM success model, shown in Figure 2.

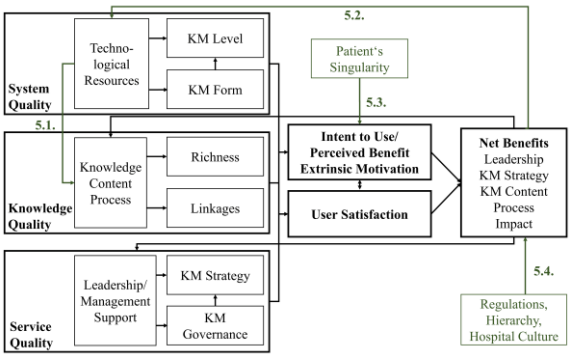

Figure 2. Health KM success model.

5.1. Finding 1: technological resources enrich knowledge quality

The participants outlined the willingness to share more knowledge or share knowledge differently if they had other technological resources (ID18, ID21). The wider introduction of visiting carts or cameras would help them to see the patient better (ID7, ID18, ID21). Moreover, the use of a patient data management system and the resulting easier ways to share patient data helps developing more precise thoughts on the patient's situation (ID4, ID20). This would lead to more intense discussions and accelerate knowledge transfer (ID4). Consequently, the consultants can prevent fixation errors or provide a more valid proposal (ID4, ID13). This effect is equally discussed in telemedicine literature (Guinemer et al., 2020; Lupton & Maslen, 2017). Lupton and Maslen (2017) emphasize the introduction of sensors for patient telemonitoring, whereas Guinemer et al. (2020) describe the efficiency of a telemonitoring dashboard. On a more general level, Strong et al. (2014) outline the positive effect of IT artifacts on physicians' behavior and actions, such as knowledge sharing. This positive impact of technological resources on the knowledge content processes requires a connection of these two aspects and, thus, a change to Jennex's (2017) KM success model. We, therefore, derive the following proposition (P):

P: Technological resources affect knowledge content processes.

5.2. Finding 2: perceived handicaps lead to the desire for more technological resources

Finding 1 partially explains the relation between the used technological resources and the net benefits, by describing that the net benefits, such as treatment quality, are higher, when mobile and interoperable technological resources are used (ID22). Before the start of the virtual hospital, some physicians already worked in another telemedical setting to treat infectious diseases (ID2, ID22). Within that system the exchange of patient data was more efficient, and consultants could control the camera in the local hospital:

"You could look at the patient yourself, zoom in on the monitor, zoom in on the ventilation parameters, look at them and then also develop a clinical view for the patients via this teleconsultation (ID22)."

This physician desired the adoption of these functionalities in the virtual hospital as he typically used half of the meeting time to exchange patient data (ID22). This would save time to focus on the patients and share more knowledge about them (ID2, ID22). Enquirers also recognized this advantage and are about to acquire patient data management system to speed up the process of patient data exchange (ID11). This reverse connection between net benefits or perceived handicap and technological resources is supported by literature. Lapointe and Rivard (2005) state the refusal of health IS use when additional tasks are added in the virtual environment. In case such tasks are done by technology itself, for example by transmitting data automatically or recognizing diseases via AI, telemedicine can expand, leading to benefits like improved patient satisfaction, safety, and streamlined processes (Ahmadi et al., 2017; Marx et al., 2022). Such a dependence further requires adjusting the KM success model by a reverse connection between net benefits and technological resources.

P: Net benefits and the perceived benefits affect the technological resources.

5.3. Finding 3: strategy and patient's singularity affect intent to use

The virtual hospital's strategy is to enable teleconsultations for single Covid-19 requests (ID2, ID3). Thus, the interviewees used the teleconsultations for Covid-19 specific, complicated questions on a singular patient (ID8, ID22). Some consultants regarded this strategy as contradictory to a KM system because it hinders a frequent knowledge sharing approach (ID8, ID18). The focus on single cases raises the question of changing the KM strategy and extending teleconsultation to other KM forms, which are frequently executed in hospitals in person, such as daily rounds (ID18). The introduction of virtual daily rounds would shift the intent to use towards a regular control measure, doublechecking the treatment approach. This would lead to further net benefits, such as the standardization of the treatment quality within the virtual hospital's platform (ID18).

Nevertheless, the current strategy of the virtual hospital also shows potential as consultants described multiple teleconsultations with the same enquirer because of the singularity of each patient (ID13, ID19). Depending on the patient's history, physicians can select different treatment options:

"Every patient is unique. There can be questions upcoming, which are different for that patient than for others (ID13)."

Medicine differs from science, as it is not exactly predictable:

"Medicine is not an exact natural science, where you can say that you will die in three days. (...) it's always a case-by-case decision, and there are also many things that go into these decisions (ID22)."

This statement shows both a barrier to and an incubator for KM in healthcare. On the one hand, decisions regarding one patient cannot be equally transferred to another one. On the other hand, physicians will more frequently collaborate on and exchange information about a patient and, thus, use teleconsultations. Zanaboni and Wootton (2012) even stress this assumption by claiming that physicians have to perceive a solution for their medical issue to adopt a technology. Greenhalgh et al. (2014) also identify the need to implement individualized patient care and clinical judgements into IS, developing evidence-based medicine IS.

Consequently, both the KM strategy and the patient's singularity affect the intent to use a teleconsultation and propose a change to Jennex's (2017) KM success model.

P: The patient's singularity affects intent to use.

5.4. Finding 4: physicians' autonomy and hospital culture affect perceived benefits

The observed virtual hospital is based in a European state in which the treating physician is fully autonomous in care of the patient (ID18). This can be beneficial, as the local physician knows the patient's history better than the consultant, who only gained a single snapshot of the patient's current condition, but also marks an issue for the KM success of the virtual hospital (ID17, ID18, ID21). In case the enquirer ignores the consultant's decision, this leads to a lower level of standardization and a non-use of high-level expertise knowledge (ID18). The local hospitals' hierarchical structure also affects the use or non-use of the proposal (ID18). In case a higher-level physician contradicts the proposal, it will not be applied (ID18). This example shows the persuasion required of every physician included in the patient's treatment. Whereas in other fields management can convince employees to use a KM system (Usoro & Abiagam, 2018), physicians have to be self-convinced and, accordingly, decide whether the specific KM system would help them treating patients better. Hence, the sustainable use of teleconsultations depends in part on the specific medical and clinical culture. Confirming this finding, Rodziewicz et al. (2022) outline the required change of the hospital culture from a culture of justification to a culture which focuses on system improvement and the identification of medical errors. Moreover, on a legal basis, several studies question how the physicians' accountability within teleconsultations is handled in future (e.g., Bragin & Cohen, 2021). These examples show specific regulations, individual hierarchical structures, and culture in hospitals influencing KM success.

P: Regulations, hierarchical structure, and culture in hospitals affect the perceived benefits, user satisfaction and net benefits.

6. Limitation and future research

In this study, we asked consultants and enquirers to participate voluntarily. In total, we conducted more interviews with consultants. Furthermore, the participating enquirers seem to present an affirmative selection regarding our research goal. Some of these community hospitals are affiliated to one of the teaching hospitals or participated in previous teleconsultation projects. To identify why physicians did not use the KM system virtual hospital, it is equally important to include physicians who did not participate. A future study should include more enquirers and their thoughts on the virtual hospital's

platform to further identify factors leading to the ignorance of these services.

The virtual hospital that we studied offered Covid-19 teleconsultations in its beginning phase and plans to include more indications in its portfolio. The same setting can be used for other communicable diseases, such as monkeypox. Further indications, such as rare diseases, require the incorporation of the patient and other physicians' competencies. Future research should prove if the findings within this use-case are universally valid for a health KM system.

Moreover, the participants regarded further areas of medicine, such as neurology, as suitable for teleconsultations (ID11). This example outlines the need to identify other beneficial fields of virtual hospitals.

7. Conclusion and contribution

Both the enquirers and the consultants personally shared knowledge via teleconsultations. By applying the factors of Table 1 and Jennex's (2017) KM success model, we identified factors which explain the use of the virtual hospital and reduce the uncertainty of KM success in healthcare initiatives. We recognized healthcare peculiarities, for example the patient's singularity, the physician's autonomy, and the hospital culture affecting KM success. The knowledge sharing optimized patient transfers and reduced the patients' mortality rate. Despite these healthcare-specific findings, general KM propositions, such as the supposed connection between technological resources and knowledge content processes, also arises. When consultants receive a more holistic picture of the patient, the richness of the shared knowledge increases. This leads to a more valid, sometimes lifesaving proposal.

This research contributes to KM research in healthcare by providing peculiarities which are essential for the use of health KM systems. Our research proposes the development of a health KM success model and, thus, enriches the research stream of information and communication technologies implications for service sector organizations (Barrett et al., 2015). The findings of this study are beneficial for the implementation of other interorganizational service delivery systems in general, and telemedicine in specific, in leading to wider acceptance, use and increased knowledge sharing (Barrett et al., 2015).

8. References

Agrawal, A., & Mukti, S. K. (2020). Knowledge Management & It's Origin, Success Factors, Planning, Tools, Applications, Barriers and Enablers. *International Journal of Knowledge Management*, *16*(1), 43–82.

Ahmadi, H., Nilashi, M., Shahmoradi, L., & Ibrahim, O. (2017). Hospital Information System adoption: Expert perspectives on an adoption framework for Malaysian public hospitals. *Computers in Human Behavior*, *67*, 161–189.

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly*, *25*(1), 107–136.

Alazmi, M., & Zairi, M. (2003). Knowledge management critical success factors. *Total Quality Management & Business Excellence*, *14*(2), 199–204.

Armfield, N. R., Edirippulige, S. K., Bradford, N., & Smith, A. C. (2014). Telemedicine - is the cart being put before the horse? *The Medical Journal of Australia*, *200*(9), 530–533.

Baird, A., Angst, C., & Oborn, E. (2020). Health Information Technology. *MIS Quarterly Research Curations.* Advance online publication.

Barrett, M., Davidson, E.J., Prabhu, J., & Vargo, S.L. (2015). Service innovation in the digital age: key contributions and future directions. *MIS Quarterly*, *39*(1), 135-154.

Bokolo, A. J. (2021). Exploring the adoption of telemedicine and virtual software for care of outpatients during and after COVID-19 pandemic. *Irish Journal of Medical Science*, *190*(1), 1–10.

Bragin, I., & Cohen, D. T. (2021). Certified Examination Assistants in the Age of Telemedicine: A Blueprint Through Neurology. *JMIR Medical Education*, *7*(4).

Chen, L., Baird, A., & Straub, D. (2019). An Analysis of the Evolving Intellectual Structure of Health Information Systems Research in the Information Systems Discipline. *Journal of the Association for Information Systems*, *20*(8), 1023–1074.

Davenport, T., Delong, D., & Beers, M. (1998). Successful Knowledge Management Projects. *Sloan Management Review*, *39*, 43–57.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319–339.

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. *Journal of Management Information Systems*, *19*(4), 9–30.

Fishbein, M., & Ajzen, I. (2009). *Predicting and changing behavior: The reasoned action approach*. Psychology Press.

Greenhalgh, T., Howick, J. & Maskrey, N. (2014). Evidence-based medicine: a movement in crisis? *BMJ*, *348*.

Greenhalgh, T., Wherton, J., Shaw, S., & Morrison, C. (2020). Video consultations for covid-19. *BMJ*, *368.*

Guinemer, C., Boeker, M., Weiss, B., Fuerstenau, D., Balzer, F., & Poncette, A.-S. (2020). Telemedicine in Intensive Care Units: Protocol for a Scoping Review. *JMIR Research Protocols*, *9*(12).

Ha, S.-T., Lo, M.-C., & Wang, Y.-C. (2016). Relationship between Knowledge Management and Organizational Performance: A Test on SMEs in Malaysia. *Procedia - Social and Behavioral Sciences*, *224*, 184–189.

Jennex, M. (2017). Re-Examining the Jennex Olfman Knowledge Management Success Model. In Bui, T. X. & Sprague, R. H. (Eds.), *Proceedings of the 50th Hawaii International Conference on System Sciences*, pp. 4375–4384.

Karamat, J., Shurong, T., Ahmad, N., Afridi, S., Khan, S., & Mahmood, K. (2019). Promoting Healthcare Sustainability in Developing Countries: Analysis of Knowledge Management Drivers in Public and Private Hospitals of Pakistan. *International Journal of Environmental Research and Public Health*, *16*(3), 508–532.

Kulkarni, U., Ravindran, S., & Freeze, R. (2007). A Knowledge Management Success Model: Theoretical Development and Empirical Validation. *Journal of Management Information Systems*, *23*(3), 309–347.

Lapointe, L, & Rivard, S. (2005). A Multilevel Model of Resistance to Information Technology Implementation. *MIS Quarterly, 29(3).*

Liu, S.-C., Olfman, L., & Ryan, T. (2005). Knowledge Management System Success. *International Journal of Knowledge Management*, *1*(2), 68–87.

Lupton, D., & Maslen, S. (2017). Telemedicine and the senses: A review. *Sociology of Health & Illness*, *39*(8), 1557–1571.

Marx, G., Greiner, W., Juhra, C., Elkenkamp, S., Gensorowsky, D., Lemmen, S., Englbrecht, J., Dohmen, S., Gottschalk, A., Haverkamp, M., Hempen, A., Flügel-Bleienheuft, C., Bause, D., Schulze-Steinen, H., Rademacher, S., Kistermann, J., Hoch, S., Beckmann, H.-J., Lanckohr, C., . . . Deisz, R. (2022). An Innovative Telemedical Network to Improve Infectious Disease Management in Critically Ill Patients and Outpatients: Stepped-Wedge Cluster Randomized Controlled Trial. *Journal of Medical Internet Research*, *24*(3).

Mayring, P. (2014). *Qualitative Content Analysis: Theoretical Foundation, Basic Procedures and Software Solution*. Beltz.

Naeem, I., Quan, H., Singh, S., Chowdhury, N., Chowdhury, M., Saini, V., & Tc, T. (2022). Factors Associated With Willingness to Share Health Information: Rapid Review. *JMIR Human Factors*, *9*(1).

Nicolini, D., Powell, J., Conville, P., & Martinez-Solano, L. (2008). Managing knowledge in the healthcare sector. A review. *International Journal of Management Reviews*, *10*(3), 245–263.

Peine, A., Paffenholz, P., Martin, L., Dohmen, S., Marx, G., & Loosen, S. H. (2020). Telemedicine in Germany During the COVID-19 Pandemic: Multi-Professional National Survey. *Journal of Medical Internet Research*, *22*(8).

Petter, S., DeLone, W., & McLean, E. (2008). Measuring information systems success: models, dimensions, measures, and interrelationships. *European Journal of Information Systems*, *17*(3), 236–263.

Rodziewicz, T. L., Houseman, B., & Hipskind, J. E. (2022). Medical Error Reduction and Prevention. In *StatPearls.* Symposium conducted at the meeting of StatPearls Publishing.

Sarker, S., Chatterjee, S., Xiao, X., & Elbanna, A. (2019). The Sociotechnical Axis of Cohesion for the IS Discipline: Its Historical Legacy and its Continued Relevance. *MIS Quarterly*, *43*(3), 695–719.

Sitammagari, K., Murphy, S., Kowalkowski, M., Chou, S.-H., Sullivan, M., Taylor, S., Kearns, J., Batchelor, T., Rivet, C., Hole, C., Hinson, T., McCreary, P., Brown, R., Dunn, T., Neuwirth, Z., & McWilliams, A. (2021). Insights From Rapid Deployment of a "Virtual Hospital" as Standard Care During the COVID-19 Pandemic. *Annals of Internal Medicine*, *174*(2), 192–199.

Strong, D., Volkoff, O., Johnson, S., Pelletier, L., Tulu, B., Bar-On, I., Trudel, J., & Garber, L. (2014). A Theory of Organization-EHR Affordance Actualization. *Journal of the Association for Information Systems*, *15*(2), 53–85.

Tornatzky, L. G., & Fleischer, M. (1990). *The processes of technological innovation*. *Issues in organization and management series*. Lexington Books.

Udeh, C., Udeh, B., Rahman, N., Canfield, C., Campbell, J., & Hata, J. S. (2018). Telemedicine/virtual ICU: Where Are We and Where Are We Going? *Methodist DeBakey Cardiovascular Journal*, *14*(2), 126–133.

Usoro, A., & Abiagam, B. (2018). Culture effect on knowledge management adoption in Nigerian hospitality industry. *VINE Journal of Information and Knowledge Management Systems*, *48*(3), 314–332.

Wang, H., Liang, L., Du, C., & Wu, Y. (2021). Implementation of Online Hospitals and Factors Influencing the Adoption of Mobile Medical Services in China: Cross-Sectional Survey Study. *JMIR MHealth and UHealth*, *9*(2).

Weeger, A., Wagner, H.-T., Gewald, H., & Weitzel, T. (2021). Contradictions and Interventions in Health IS. *Business & Information Systems Engineering*, *63*(6), 689–710.

Wilson, L. S., & Maeder, A. J. (2015). Recent Directions in Telemedicine: Review of Trends in Research and Practice. *Healthcare Informatics Research*, *21*(4), 213–222.

World Health Organization. (2010). *Telemedicine: Opportunities and Developments in Member States. Report on the Second Global Survey on eHealth 2009*. *Global Observatory for Ehealth*. World Health Organization.

Zanaboni, P., & Wootton, R. (2012). Adoption of telemedicine: From pilot stage to routine delivery. *BMC Medical Informatics and Decision Making*, *12*(1).