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You Are Not Alone! Care Professionals' Acceptance of Telemedicine in Nursing Homes Comparing Pre- and Post-Implementation Evaluations

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Abstract: A lack of personnel in care institutions and high proportions of older people in need of care pose central challenges for today's aging society, often resulting in the hospitalization of geriatric patients. In many cases, these hospitalizations are not medically necessary and cause deterioration of health. Applying telemedicine in nursing homes represents one approach aimed at a reduction of unnecessary hospitalizations of geriatric patients and supporting care personnel in medically uncertain situations. For a sustainable and successful implementation of technical innovations such as telemedical consultations, the care personnel's perspectives and acceptance are especially essential. The Optimal@NRW project implemented telemedical consultations in 24 nursing homes in Germany, investigating medical and economic efficiency and in particular also the social acceptance of digital care in nursing homes. This paper presents quantitative results comparing the acceptance evaluations before (PRE: N = 130) and after (POST: N = 87) the implementation of the telemedical consultations in the nursing homes from the perspective of care professionals. The results showed positive evaluations of the telemedical consultations in both evaluation phases: POST evaluations especially showed a lower evaluation of perceived barriers of using telemedical consultations in nursing homes. This study's insights enable one to derive guidelines and recommendations regarding the communication and information of telemedical applications considering the needs and wishes of care personnel as a central user group.

Keywords: technology acceptance; telemedicine; nursing homes; care professionals; pre-post-evaluations

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1. Introduction

The demand for the care of geriatric patients has constantly risen due to demographic change and resulting increases in (multiple) chronic diseases and care dependency [1–3]. Thereby, shortages of skilled care professionals contrast with a too high proportions of geriatric patients in need of care, leading to high burdens in the care sector [4]. Focusing on the most vulnerable group of geriatric patients in nursing homes, acute medical emergency care for geriatric patients needs to be considered since acute situations in nursing homes often lead to unnecessary hospitalizations. This is particularly the case outside the hours during which general practitioners are typically available for consultation [5,6]. Telemedical consultations in acute situations in nursing homes have the potential to relieve care personnel and to reduce unnecessary hospitalizations of geriatric patients. However, the social acceptance of using telemedicine in nursing homes is essential. Therefore, this paper analyzes care professionals' acceptance of using telemedical consultations in acute situations in nursing homes, comparing evaluations prior and after the implementation of the telemedical equipment and processes.

The paper is structured as follows: First, the theoretical background and the resulting research gap the underlying research project focuses on as well as the specific hypotheses being addressed in this paper are described. Following that, the empirical design is presented, including the specific characteristics of the questionnaire design and the sample. Then, the results are described comparing pre- and post-implementation evaluations. Finally, the results are discussed and recommendations for future development and research on telemedical approaches are derived.

1.1. Motivation

Prior research on the hospitalization of geriatric patients has demonstrated that approximately 20% of nursing home residents are hospitalized at least once annually. Furthermore, 40% of these hospitalizations were identified as premature or unnecessary [5,7].

In addition to emotional stress caused by these hospitalizations, the usually long waiting times in emergency departments, representing an unfamiliar environment, frequently trigger delirium: in particular in patients with dementia, higher levels of dependency due to frailty represent the consequences of the hospitalizations [8,9]. This effect is observed especially outside the regular consultation hours of primary care physicians in combination with the increasing workloads of care personnel in nursing homes (e.g., low proportion of personnel during night shifts). The main reasons for these so called "ambulatory-care sensitive conditions" have not been finally clarified, but it can be assumed that sub-optimal outpatient medical care of the nursing home residents (e.g., shortages of personnel, poor accessibility, and coverage by primary care physicians) seems to be responsible. Technical solutions have the potential to address precisely these problems.

1.2. Telemedicine as Potential Solution

Applying digital approaches has the potential to address the main challenges caused by demographic change in terms of delivering care to geriatric patients in acute situations and relieving the care personnel [10,11]. The value and meaning of information and communication technologies (ICT) for healthcare applications in line with their socioeconomic benefits in healthcare have been highly acknowledged in recent years [12]. This has led to numerous developments and research projects focusing on eHealth and telemedical applications, being fueled of course by the necessity of alternative solutions during the COVID-19-pandemic [13,14].

Telemedicine refers to patient-centered healthcare services being delivered with the involvement of healthcare providers. It uses ICT [15] and covers a broad range of applications, such as those addressing doctor–patient communication to applications for communication between medical professionals, such as telemedical intensive care [16] or telemedical emergency care [17]. Beyond that, telemedical applications use advanced control methods and sensor fusion to assist medical professionals during complex surgeries [18,19].

Such approaches have multiple benefits, but also (perceived) barriers that may influence the final acceptance and decision to use the technologies. The most prominent arguments are summarized in the following. Overall, telemedicial approaches are applied to improve healthcare delivery. With regard to geriatric care, one major benefit of using telemedicine lies in an improved access of geriatric patients to healthcare, enabled by remotely connecting with physicians [20,21]. Other benefits of using telemedical approaches include an enhanced quality of healthcare and more efficient health care services [22]. Central benefits lie also in the efficiency and added safety of telemedical consultations compared to conventional care. Here, advanced control methods and continuous monitoring enable safe and effective operations of telemedical services. Beyond the benefits telemedical applications bring along, there are barriers and concerns that frequently lead to telemedicine projects not being pursued after their test phase and not being established in regular care processes [23]. Exemplary barriers often refer to the time and financial resources of handling the telemedical processes, technical infrastructure, preferences for consultations on site, or ethical concerns [24,25].

Numerous telemedicine and eHealth approaches are funded as national and international research projects. For example, the EU project PAAL (Privacy-Aware and Acceptable Lifelogging services for older and frail people) focused on developing and analyzing different video-, sensor-, and speech-based systems, aiming at a support of older and frail people in their everyday lives [26]. The project AIDA represented another example in Germany, focusing on the medical care of nursing home residents. It was aimed at the preparation of nursing homes for using telemedicine to ensure adequate care for older people [27].

Despite the potential and benefits of technical solutions and promising research projects, it is still difficult to successfully realize the transfer of project phases into the standard care processes of national health insurance funds. Beyond financial, structural, and organizational difficulties, the acceptance of all involved stakeholders—especially professional caregivers, patients, and physicians—represents a relevant prerequisite for the successful and sustainable implementation of usable telemedical approaches and applications in care settings.

1.3. Acceptance and Perception of Telemedicine

Research on technology acceptance and use has intensively increased over the last few decades in very diverse disciplines, e.g., psychology, social sciences, or business economics. The majority of the approaches concentrated on the willingness to use technology as well as using conditions and human factors as potential influencing factors on acceptance. As the most established and successful acceptance models, the TAM [28] and UTAUT [29] originated from the ICT working context, but they are frequently applied and adapted to different contexts, in particular also to technologies being used for healthcare [30]. However, these models focused in particular on two relevant parameters as good predictors for the behavioral intention to use a specific technical application: the perceived ease of use and perceived usefulness. Hence, it can be critically argued that they disregard technology- or context-specific parameters. Beyond that, research on the acceptance of assisting technologies showed that specific perceived benefits and barriers are also relevant for the acceptance and willingness to use [31]. Therefore, specific perceived benefits and barriers should also be considered, identified, and quantified for the specific application of using telemedical consultations in nursing home settings.

Focusing on the specific application of using telemedical technologies, research (e.g., [15,32]) has validated the central dimensions of the TAM model, i.e., perceived ease of use and perceived usefulness, as impacting parameters on the attitude towards telemedicine and the concrete behavioral intention to use telemedicine. In addition, technological anxiety, social influence, trust, facilitating conditions, perceived risk, and resistance to technology were identified as relevant factors for the acceptance of telemedicine [32]. Other studies [33,34] have revealed that the experiences with telemedicine, e.g., in terms of trust, satisfaction with the telemedical services, and information quality, are decisive for the acceptance and intention to use: they have the potential to influence the acceptance and evaluations positively. These results suggest that evaluations of telemedicine may differ depending on having or not having previous hands-on experiences with the respective telemedical application.

Beyond these rather general aspects, previous research on the acceptance of assisting health technologies has shown that individual human factors also impact perceptions and acceptance. In more detail, demographics, technology expertise, and care experience were identified as relevant influencing factors (e.g., [35,36]). With regard to the latter, previous research identified that care professionals have more restrained attitudes towards assistive applications and telemedical approaches compared with other user groups [36]. The implementation and sustainable usage of innovative technological approaches in nursing homes can only be successfully realized if the respective care personnel is willing to use it. Hence, individual factors and in particular the perspective of care professionals should be taken into account when the acceptance of telemedical applications is analyzed.

1.4. Research Gap and Hypotheses

Overall, previous research on the acceptance of telemedical approaches has predominantly focused on hospital settings (e.g., [30,34]) or private home settings, addressing a rather generic population [32]. In contrast, analyzing care professionals' acceptance of telemedical consultations in nursing homes to support the care of geriatrc patients in acute situations has hardly been investigated. Therefore, it was one central aim of the underlying Project Optimal@NRW to analyze the acceptance of using telemedical consultations in nursing homes, comparing initial perceptions and attitudes with perceptions and acceptance after having the opportunity to use telemedical consultations in acute situations on a regular basis.

Based on previous research [33,34]—suggesting that usage experience has positive effects on the acceptance and evaluation of using telemedical applications—the following hypotheses were derived:

H1. *Care professionals' acceptance is higher in post-implementation evaluations compared to pre-implementation evaluations.*

H2. *Care professionals' assessment of perceived benefits is more positive in post-implementation evaluations compared to pre-implementation evaluations.*

H3. *Care professionals' assessment of perceived barriers is less negative in post-implementation evaluations compared to pre-implementation evaluations.*

H4. *Care professionals' assessment of conditional requirements is lower in post-implementation evaluations compared to pre-implementation evaluations.*

H5. *Explaining factors for care professionals' acceptance differ depending on pre- and post-evaluations.*

2. Materials and Methods

This section described the empirical design of our conducted studies, starting with the underlying project's course and the overall empirical approach. Subsequently, the study design of the pre- and post-implementation assessments are detailed, followed by the procedures of data analysis as well as the characteristics of the sample.

2.1. Project Course and Empirical Approach

Although the number of projects focusing on telemedical applications has increased in recent years, previous projects and technical solutions have neither been realized in terms of a concrete transfer to standard care of the national health insurance nor have been rolled out large-scale. Therefore, central tasks for current and future research lie in an implementation and standardization of telemedical applications and processes, proof of medical evidence, and analyzing ways of cost coverage by health insurance companies, as well as the investigation of acceptance of all involved stakeholders. These tasks are necessary, aiming at a sustainable use and adoption of telemedicine in nursing homes.

The underlying research project Optimal@NRW (for more details, see [37]) addressed these tasks by representing an intersectoral approach providing acute care and support for geriatric patients realized by telemedical consultations in 24 nursing homes. In particular, the super-ordinate aim of the project focused on the reduction of inadequate hospital admissions in ambulatory care-sensitive hospital cases and improved medical care in nursing homes. Technical and medical details are considered separately and can be studied here [37].

In addition to medical research perspectives and an evaluation of the economic efficacy of the implemented processes, the project also integrated a social communication science perspective. In this regard, empirical research approaches realized assessments of

user-related acceptance by investigating the perceptions, requirements, and wishes of the relevant stakeholders, i.e., the residents of nursing homes and their care personnel.

The actions and opinions of the care personnel determined whether processes and structures were sustainably applied in the professional everyday life in nursing homes. Therefore, it was precisely the perspective of this specific user group that was aimed at and had to be considered, analyzed, and understood within the entire project.

The entire project, including all studies of the different project partners, was reviewed and approved by the Ethics Committee at the RWTH Aachen Faculty of Medicine. As mentioned above, 24 nursing homes participated in the project. Inclusion criteria for the geriatric patients—who were not focused on as participants in the study presented here—were detailed in [37]. Beyond that, all care professionals working in the 24 nursing homes had the opportunity to take part in the empirical studies regarding the acceptance and evaluation of the telemedical consultations. Participation was voluntary, and there were no exclusion criteria for the participant group of care professionals.

Overall, three phases of the project had to be distinguished: pre-implementation, implementation, and post-implementation. In each of the three phases, technology acceptance and perception were investigated, applying multi-faceted empirical approaches consisting of qualitative interview and quantitative survey studies. Within these studies, the perspectives of the geriatric patients (predominantly in qualitative studies) and in particular the perspectives of care professionals were focused on. In this paper, the quantitative results comparing the care personnel's evaluation of the pre- and the post-implementation phases are presented.

2.2. Questionnaire Design

In both phases, a questionnaire was used to collect the opinions and assessments of the care personnel. As only small proportions of the nursing homes had the opportunity to provide the questionnaire online to their care personnel, the majority of the respondents filled out printed paper questionnaires.

The questionnaire consisted of three parts. In the first part, the participants were asked for demographic information such as their age, gender, living situation, and current occupation. In addition, the participants indicated previous care experiences as well as the duration they had worked at their respective nursing homes.

In the second part, a description of the underlying project and the telemedical infrastructure—the ones the participating care professionals were working with—was provided as a baseline for the subsequent assessment of the telemedical consultations. These descriptions and visualizations were kept constant for both questionnaires (pre and post) and are detailed below (also already referenced in [38]):

> *"In the Optimal@NRW project, telemedical technology is being introduced and tested in various nursing homes in the region of Aachen. Once introduced, it will be possible for the on-site care personnel to request support in emergency situations via the central emergency number (116117) of the Association of Statutory Health Insurance Physicians. The trained staff at the center will decide whether the specific case is suitable for teleconsultation or whether another step must be taken. If the requirements for a teleconsultation are met, a wheeled stand equipped with a camera, monitor, microphone, and specific medical technology equipment (for measuring blood pressure, oxygen saturation, pulse, and temperature) is pushed into the patient's room. Then, a specialist is available in a time period of maximum 10 min. The physician can communicate live with the patient and the care personnel and view the electronic patient file. Once the patient's medical history has been taken, the telemedicine specialist decides on the next course of action. If necessary, he or she can, for example, order the deployment of a specially trained mobile nurse to the nursing home, who can then carry out interventions on site, such as changing a catheter. Actions such as these can prevent a resident from being rushed to hospital, instead of being able to remain in their familiar environment. At the same time, long waiting times for the difficult-to-reach general practitioners or specialists should be avoided."* [38]

The third part focused on the participants' assessment of the telemedical consultations. For this purpose, the participants evaluated their attitude towards telemedical consultations based on three items (Cronbach's α = .97) as well as their intention to use the telemedical consultations, also based on three items (Cronbach's α = .85). The assessed items were presented in Figure 1. Further, perceived benefits of using telemedical consultations were assessed based on 10 items (Cronbach's α = .96; all items are presented in Figure 2), just like the evaluation of perceived barriers (Cronbach's α = .94; all items are presented in Figure 3). In addition, the participants evaluated relevant conditionals of using telemedical consultations based on five items (Cronbach's α = .92). The respective items are presented in Figure 4. All these measured items (referring to the evaluation of the telemedical consultations) were assessed on six-point Likert scales (min = 1; max = 6), whereas the value of 3.5 represented the mid-point of the scale. Hence, values < 3.5 indicated rejection, while values > 3.5 indicated acceptance of an item/benefit/barrier/conditional requirement.

Finally, we thanked the participants for their time spent with our empirical studies, and the participants had the opportunity to provide feedback on the topic, the project, or the questionnaire on an optional basis.

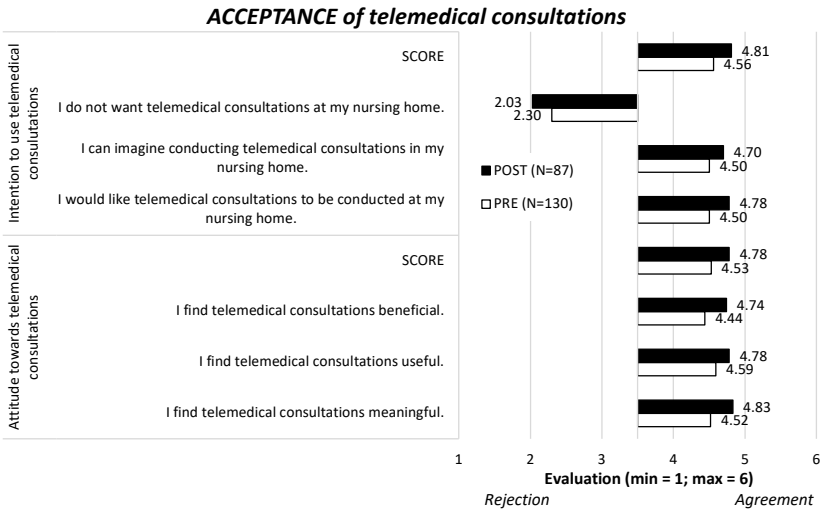

Figure 1. Acceptance of telemedical consultations comparing PRE and POST evaluations.

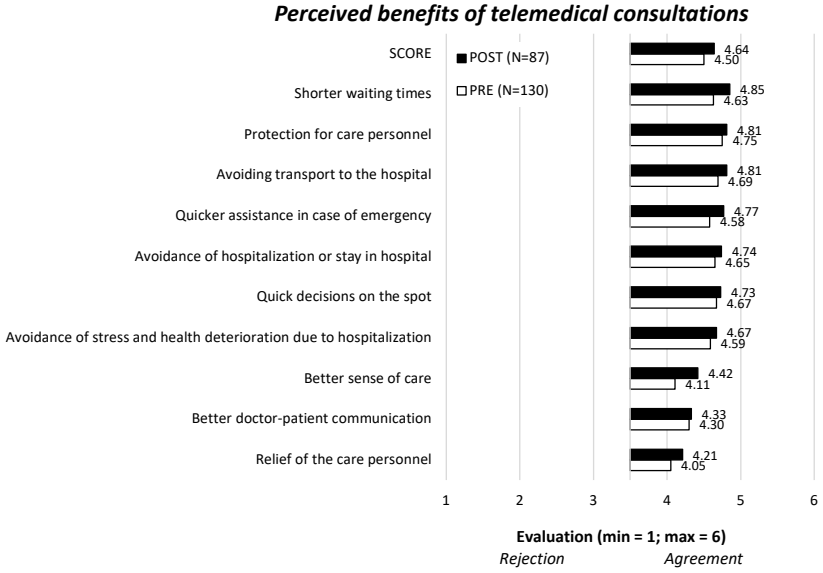

Figure 2. Perceived benefits of telemedical consultations comparing PRE and POST evaluations.

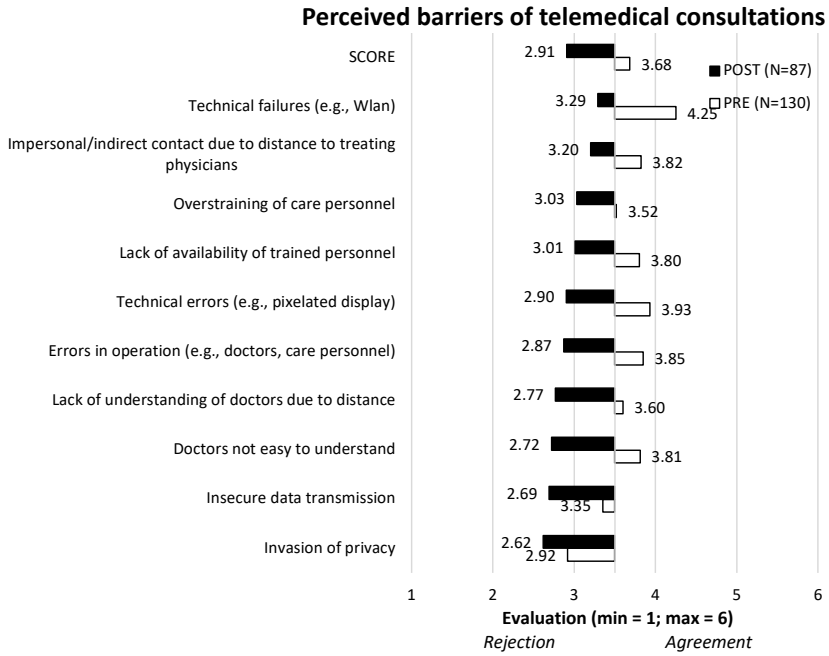

Figure 3. Perceived barriers of telemedical consultations comparing PRE and POST evaluations.

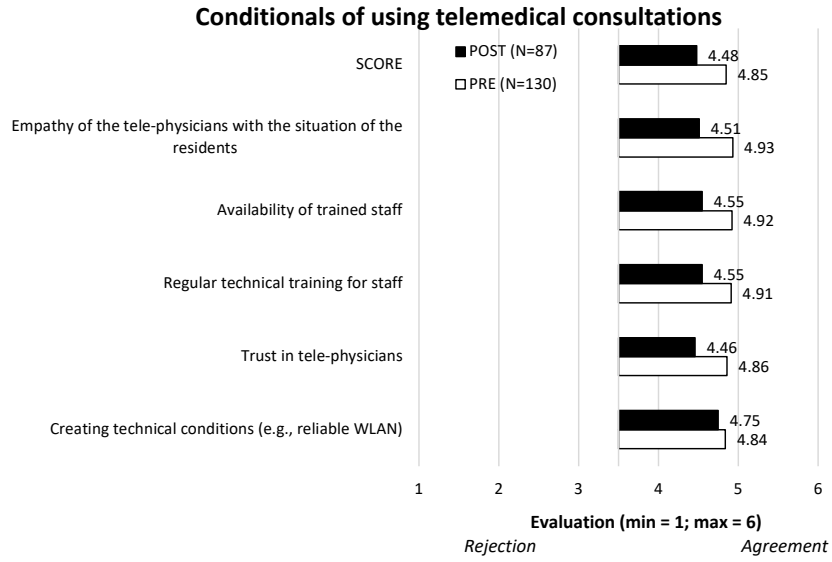

Figure 4. Conditionals of using telemedical consultations comparing PRE and POST evaluations.

2.3. Data Analysis

Reliability analyses (Cronbach's $\alpha > 0.7$) ensured the quality of all measured constructs (i.e., intention to use, attitude towards telemedical consultations, perceived benefits, perceived barriers). In addition to descriptive statistics (means (M), standard deviations (SD), and relative frequencies (%)), analyses of variance (ANOVA) were used to investigate differences between the assessment before and after the implementation and usage of the telemedical consultations. Thereby, the F-ratio was reported as a calculated test statistic. For the analysis of relationships between the investigated constructs, regression analyses were used separately for the pre- and post-implementation evaluations. This type of analysis was selected as it enabled the determination of the strength of the relationships between specific constructs, as well as the proportions with which variables explain a target construct [39]. Furthermore, regression analyses had fewer requirements for the samples examined and their sizes (i.e., 10 data sets per predictor) than other methods, such as structural equation

models. As both samples examined met the aforementioned requirements, regression analyses were employed. The level of significance was set at 0.05, and values above the significance level ($p > 0.05$) were interpreted as not significant (n.s.).

2.4. Characteristics of the Sample

Overall, N = 217 care professionals took part in the pre- and post-implementation studies. For the pre-implementation phase, n = 130 data sets were used, while n = 87 data sets were analyzed for examination of the post-implementation phase. The participants were, on average, 37.4 years old (SD = 12.0, min = 19, max = 65) and predominantly female (71.9%, n = 156; male: 21.2%, n = 46; diverse: 2.3%, n = 5; not indicated: 4.6%, n = 10). Related to their living situation, most of the participants reported to live together with another person (43.5%, n = 81) or with their families (40.3%, n = 75), while only 16.1% (n = 30) indicated living alone (not indicated, n = 31). The participants were additionally asked for previous private care experience outside the professional everyday life: here, 33.2% (n = 72) indicated that a person in their close environment was in need of care (passive experience) and 60.4% (n = 131) participants reported that they had already cared for a person in need of care in their close environment (active experience). Related to their professional experience, 16.8% (n = 32) reported working in their nursing home for less than one year, while more participants reported working there for between 1 and 3 years (29.8%, n = 57), between 5–10 years (27.2%, n = 52), or even more than 10 years (26.2%, n = 50 and not indicated: n = 26).

So far, the characteristics of the whole sample of participants have been introduced. As this paper is aimed at a comparison of the pre- and post-implementation evaluations, the samples of both study phases also had to be analyzed and compared. As shown in Table 1, both samples did not differ significantly regarding demographic characteristics (such as age, gender, or living situation) nor considering care-related aspects (i.e., private active and passive care experience, duration of working in their specific nursing homes). Hence, both samples had similar distributions of all characteristics and allowed a comparison of both studies, with them not being influenced by unequal distributions.

Table 1. Characteristics of samples depending on pre- and post-implementation.

Variable		PRE (n = 130)	POST (n = 87)	Statistical Difference
Age	M(SD)	38.7 (12.4)	35.6 (11.2)	F(1,210) = 3.656; p = .06; n.s.
Gender	female male diverse not indicated	75.4% (n = 98) 20.8% (n = 27) 3.8% (n = 5) –	75.3% (n = 58) 24.7% (n = 19) – n = 10	F(1,206) = .280; p = .597; n.s.
Living Situation	with 1 person with family alone not indicated	44.1% (n = 56) 38.6% (n = 49) 17.3% (n = 22) n = 3	42.4% (n = 25) 44.1% (n = 26) 13.6% (n = 8) n = 28	F(1,185) = .676; p = .412; n.s.
Active Care Exp.	yes no	60.8% (n = 79) 39.2% (n = 51)	59.8% (n = 52) 40.2% (n = 35)	F(1,216) = .319; p = .532; n.s.
Passive Care Exp.	yes no	31.5% (n = 41) 68.5% (n = 89)	35.6% (n = 31) 64.4% (n = 56)	F(1,216) = .022; p = .883; n.s.
Duration working in nursing home	<1 year 1–3 years 5–10 years >10 years not indicated	21.8% (n = 27) 29.8% (n = 37) 21.8% (n = 27) 26.6% (n = 33) n = 6	7.5% (n = 5) 29.9% (n = 20) 37.3% (n = 25) 25.4% (n = 17) n = 20	F(1,190) = 3.364; p = .068; n.s.

3. Results

Within this section, the results of the pre- and post-implementation evaluations are described. First of all, the comparison of both studies was focused. Subsequently, the relationships between the evaluated constructs and the impacting parameters are presented.

3.1. Comparing Pre- and Post-Evaluations (H1–4)

As a baseline, the results related to the acceptance of using telemedical consultations in nursing homes are presented to assess H1 (see Figure 1). Overall, the participants showed a positive **attitude towards telemedical consultations** ($F(1,215) = 2.197$; $p = .140$; n.s.) as well as a positive **intention to use telemedical consultations** ($F(1,215) = 2.255$; $p = .135$; n.s.), independent from the pre- and post-implementation evaluations. Beyond both constructs, this was also true for all single items.

In line with this (see Figure 2) and evaluating H2, the results of **perceived benefits** of using telemedical consultations showed an equal confirmation being not significantly influenced by the pre- and post-implementation assessments ($F(1,215) = .813$; $p = .368$; n.s.). This evaluation pattern was identified for all single items related to perceived benefits, covering general benefits such as shorter waiting times ($F(1,215) = 1.684$; $p = .196$; n.s.), personnel-related benefits like relief of the care personnel ($F(1,215) = .689$; $p = .407$; n.s.), and patient-related benefits, e.g., Avoiding of stress and health deterioration ($F(1,215) = .210$; $p = .647$; n.s.).

Perceived barriers were also assessed by the participants in relation to the pre- and post-implementation studies (H3). As can be seen in Figure 3, differences in the pre- and post-implementation evaluations are more visible compared to the evaluations of acceptance or perceived benefits. Overall, **perceived barriers** were slightly confirmed within the pre-implementation evaluation ($M = 3.68$; $SD = .96$), while a rejection ($M = 2.91$; $SD = 1.03$) was identified in the post-implementation evaluation ($F(1,215) = 31.96$; $p < .01$; $\eta^2 = 0.129$). This evaluation pattern has been identified for all single barriers except for invasion of privacy, which was overall rejected and not evaluated differently depending on the pre- and post-implementation studies ($F(1,215) = 3.094$; $p = .08$; n.s.). The most striking differences were found for barriers related to the technical realization and handling in terms of technical failures ($F(1,215) = 28.00$; $p < .01$; $\eta^2 = .115$, technical errors ($F(1,215) = 35.41$; $p < .01$; $\eta^2 = .141$), errors in operation ($F(1,215) = 31.69$; $p < .01$; $\eta^2 = .128$), and in particular the concern that doctors are not easy to understand ($F(1,215) = 39.68$; $p < .01$; $\eta^2 = .156$). All these barriers have in common the fact that they received the participants' agreement in the pre-implementation phase and were slightly to clearly rejected in the post-implementation evaluation. All other single barriers showed this evaluation pattern, but at a less pronounced level ($\eta^2 < .10$).

In addition to their acceptance, perceived benefits, and barriers, the participants also evaluated relevant **conditionals of using telemedical consultations** (Figure 4, H4). The results showed slight differences between the pre- and post-implementation evaluations, revealing higher confirmations ($F(1,208) = 3.479$; $p < .05$; $\eta^2 = .023$) of the conditionals within the pre-implementation phase ($M = 4.85$; $SD = .88$) compared to the post-implementation evaluation ($M = 4.48$; $SD = .83$). This pattern was found for all single conditionals on a similar level, except for creating technical conditions ($F(1,206) = .361$; $p = .549$; n.s.), which was similarly confirmed independent from the two evaluation phases.

3.2. Relationships and Impacting Parameters (H5)

In the following, the results were analyzed with regard to the relationships between the acceptance and perception evaluations of using telemedical consultations as well as potential impacting factors. Figure 5 summarizes the most relevant results from regression analyses conducted separately for the pre- and post-implementation evaluations.

Starting with the pre-implementation study, the results revealed that 49.3% (adj. $r^2 = .493$) of the variance of the **attitude towards telemedical consultations** can be explained by the **perceived benefits** ($\beta = .603$; $p < .01$) and the relevant **conditionals** ($\beta = .150$;

p < .05) of using telemedical consultations. In addition, 74.3% of the variance of the concrete **intention to use telemedical consultations** can be predicted by the **attitude towards telemedical consultations** (β = .720; p < .01).

Moving to the post-implementation study, even more variance of the **attitude towards telemedical consultations** can be explained (80.3%) based on the **perceived benefits** (β = .579; p < .01) and the **perceived barriers** (β = −.330; p < .01). Beyond that, 87.0% of the variance of the **intention to use telemedical consultations** can be predicted by the **attitude towards telemedical consultations** (β = .792; p < .01).

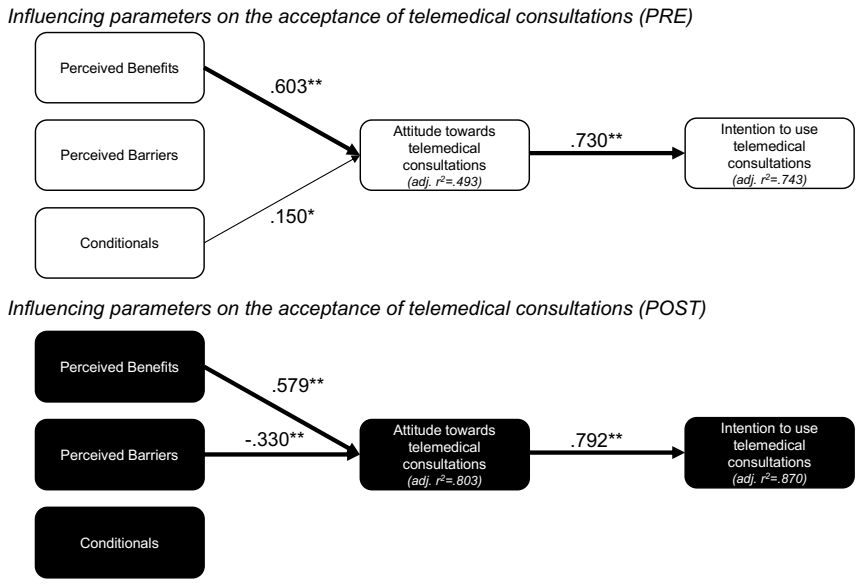

Figure 5. Influencing parameters on acceptance of using telemedical consultations comparing PRE and POST evaluations (* = p< .05; ** = p < .01).

Beyond that, MANOVA analyses were conducted in order to control for impacting parameters in terms of demographics and previous expertise. As dependent variables, we analyzed intention to use, attitude towards telemedical consultations, perceived benefits, perceived barriers, and conditionals and controlled their evaluations for the effects of age, gender, living situation, and private passive and private active care experience.

The results did not reveal any significant effect of the mentioned parameters on the evaluation of the telemedical consultations. Neither age (F(5,131) = .602; p = .698; n.s.), gender (F(5,131) = 1.483; p = .200; n.s.), living situation (F(5,131) = 1.406; p = .178; n.s.), nor private passive (F(5,131) = 2.018; p = .080; n.s.) and private active (F(5,131) = 1.859; p = .106; n.s.) care experience were confirmed to be relevant impacting parameters for the evaluation of telemedical consultations.

4. Discussion

The results of the empirical studies presented here are highly relevant for the understanding of telemedicine acceptance in nursing homes. Pre- and post-implementation evaluations were conducted, focusing on the perspective of care personnel working in geriatric care: thereby, it was firstly shown (for the specific case of geriatric care) that the acceptance of conducting telemedical consultations in everyday life in nursing homes was overall positively evaluated. Even more important, the results showed that (perceived) barriers decreased and were less relevant after using the telemedical consultations. In the following, the results are discussed related to previous research in the field. Based on the results, implications and recommendations were derived, and limitations as well as the potential for future work are highlighted.

4.1. Key Insights and Interpretation

Contrary to the hypotheses H1 and H2, there were no significant differences in the acceptance and evaluation (of perceived benefits) of telemedical consultations between the pre- and post-implementation evaluations. The results showed only higher evaluated acceptance scores and a higher evaluation of the perceived benefits on a descriptive, but not on a significant, level. However, the identified evaluation patterns were indicated in the hypotheses. Hence, the results regarding H1 and H2 signified an encouraging trend in the acceptance of telemedical consultations within nursing homes, reflecting a positive attitude and a favorable intention to engage with the telemedical services, acknowledging their benefits independent from the pre- and post-implementation evaluations. The positive evaluation results were in line with prior research that emphasized the growing acceptance of telemedicine and telehealth services, particularly in the context of improving healthcare accessibility and delivery, especially for vulnerable populations such as those residing in nursing homes [12,30].

Furthermore, the positive attitude and intention to use telemedical consultations suggested a promising trend in the integration of technology-enabled healthcare services, highlighting the potential benefits of telemedicine in enhancing the overall quality of care for nursing home residents. The fact that acceptance evaluations were not significantly higher in the post-implementation evaluations contradicted the assumption that the experience of interacting with the telemedical applications affects acceptance. Beyond that, the positive evaluations of the care professionals were even more special in light of the fact that care professionals have been proven to be a very restrained and critical user group in previous research [36]. Here, the hands-on experience over at least six month up to more than a year presumably supported the willingness to use and the perception of benefits using the telemedical consultations.

In contrast to the evaluations of acceptance and perceived benefits, perceived barriers (H3) were perceived significantly less negatively after using telemedical consultations. Hence, the results confirm the postulated hypothesis (H3) and also previous research [33,34] in the field: the results showed that hands-on experiences with the technology lead to more positive evaluations and reduced the perception and concerns related to the perceived barriers of using the telemedical consultations. The notable shift in the participants' perceptions—with a significant decline in the acknowledgment of barriers—suggested a growing acceptance and familiarity with the telemedical processes. The substantial decrease in concerns related to technical failures, errors, and operational difficulties underscored an enhanced understanding and proficiency in navigating the telemedicine infrastructure, indicating an improvement in the overall user experience and system functionality.

The results showed that the evaluations of conditional usage requirements (H4) were less important after using telemedical consultations. Hence, H4 can be considered as verified, and these are overall more positive evaluations based on previous experiences with the technology. These findings underscore the significance of initial expectations and perceptions of the conditions necessary for the successful implementation of telemedical applications. The relatively higher confirmations observed during the pre-implementation phase suggested that participants had established a set of expectations and prerequisites for the effective functioning of the telemedical infrastructure, indicating a proactive approach towards ensuring the technical and operational prerequisites for a seamless implementation process. Understanding these expectations and conditionals is crucial for healthcare providers and policymakers, as it provides valuable insights into the key factors that users prioritize and expect from telemedical services. This knowledge can facilitate the development of tailored strategies to meet user expectations, enhance system performance, and ultimately contribute to a more streamlined and effective integration of telemedical solutions in healthcare settings.

Beyond these evaluations, the results also revealed insights regarding the relationships between the evaluated constructs. The insights confirmed hypothesis H5, which postulated that different factors explain the care professional's acceptance depending on the pre-

and post-implementation evaluations. For the pre-implementation phase, the perceived benefits were most decisive for explaining the attitude towards telemedical consultations. In contrast, perceived benefits and a low perception of perceived barriers represented the central predictors for the attitude towards telemedical consultations. In line with previous research in the field, the attitude towards and intention to use were proven to be central elements of modelling the acceptance of telemedicine in nursing homes [15,32] and can be explained by the perceived benefits and barriers of using telemedical consultations. Contrasting previous studies, e.g., [35], the results showed that individual factors are not decisive compared to the experiences with the technology in terms of the pre- and post-implementation evaluations.

4.2. Implications and Recommendations

First of all, the results showed that hands-on experience is decisive. Enabling someone to interact with technology allows the enhancement of familiarity and reduces potential (perceived) barriers. In line with this, it is recommended to integrate all relevant stakeholders as early as possible in the development and implementation processes of innovative healthcare technology: this way, it is possible to consider their perspectives as well as identified requirements right from the beginning and in a continuous manner.

Beyond that, the results suggested that user-centered training and support are decisive. Considering the positive trends in acceptance and the reduction of perceived barriers, it is advisable to provide user-centered training and ongoing technical support for professional caregivers in nursing homes. These training sessions can help to improve the understanding and familiarity with the telemedical infrastructure and overcome potential technical or operational hurdles.

The findings also suggest that ongoing feedback from the users, in particular the professional caregivers, should be used to further enhance telemedical applications. Integrating a structured feedback mechanism can help in identifying technical issues, optimize the user experience, and further increase user acceptance.

In this regard, a continuous monitoring and maintenance of technology infrastructure is recommended. To maintain trust in the telemedical platform in the long run, regular maintenance and monitoring of the technology infrastructure should be ensured. This includes ensuring reliable technical performance, addressing potential issues, and updating and adapting the platform according to changing requirements and user expectations.

Finally, the manner of information and communication was of utmost importance. The results emphasized the continuous need to improve communication between professional caregivers, nursing home residents, and physicians through the telemedicial platform. Integrating user-friendly interfaces and ensuring clear and understandable communication can help minimizing potential concerns about doctor–patient communication. In this regard, the information and communication of specific benefits and barriers is essential as these benefits and barriers have an enormous impact on the acceptance and attitude towards telemedical approaches. In particular, all stakeholders should be informed about the added value of using telemedical consultations, and the handling of potential barriers (e.g., privacy regulations, data handling) should be communicated transparently.

As the present findings are based on experiences during the implementation phase, conducting long-term studies on the prolonged usage and acceptance of telemedicine in nursing homes is advisable. Such long-term studies can provide insights into long-term usage patterns, potential changes in acceptance over time, and the long-term impacts of telemedicine on the nursing home community.

4.3. Limitations and Future Research

The results have contributed to a better understanding of care professionals' acceptance and perception of telemedical consultations in nursing homes, comparing initial with experienced evaluations. The ongoing studies during the use of the technology provided insights into the acceptance and difficulties encountered during the real use of the telemed-

ical care infrastructure within the daily routine of professional caregivers in nursing homes. The continuous evaluations enabled an early identification of problems and difficulties, which could be discussed with the project team at an early stage; this leads partly to an adaption of the processes, so that concrete solution strategies were developed and, as a result, initially existing problems occurred less frequently.

However, further research is needed to explore the underlying factors contributing to the positive acceptance of using telemedical consultations in nursing homes, and to address potential barriers that may affect the successful implementation and utilization of telemedicine in nursing home settings. In this regard, further longitudinal studies should focus on the acceptance of telemedical applications in nursing homes; empirical studies over a longer period of time (extending usage phases of six to 12 months) would facilitate the identification of specific driving and hindering acceptance factors that only become more important over time once the use of the technology has already become established.

A central benefit of the methodological approach during the project was the consistent inclusion of the relevant user groups as well as the individually adapted empirical procedure (e.g., adapted digital or analog formats). One limitation of the approach is certainly that it was never possible to include all participating care professionals (likewise, all nursing home residents) in the empirical studies, and thus a selection was always made in consultation with the nursing homes. This may have led to the fact that especially voices that wanted to communicate were considered in the project, and rather reserved, possibly also more critical voices, were less heard. Nevertheless, the online and paper questionnaires were generally available to all professional caregivers and enabled their participation. Future studies should specifically try to also reach those voices that are more critical and reserved. To this end, empirical qualitative methods should initially be used more frequently, as this offers the opportunity to approach and respond to individual people and their opinions. In addition, systematic observations should be used over a longer period of time, as this can also reveal in detail the problems and difficulties in using telemedical consultations that may not be explicitly mentioned by the users in interviews or questionnaires.

Related to the samples of the pre- and post-implementation evaluations, it has to be reflected that the post-evaluation sample was smaller than the sample in the pre-implementation phase. In general, it was observed that the willingness to participate in empirical studies decreased during the project period. Nevertheless, both groups had an adequate size and distribution, enabling their direct comparison. For future work, it would still be valuable to reach larger and more equal distributions to be able to conduct more detailed methodological approaches, such as structural equation modeling. Such approaches would provide a more comprehensive understanding of the complex relationships between the investigated variables and allow for the analysis of direct and indirect effects simultaneously. Beyond that, structural equation modeling offers the benefit of assessing the overall model fit, ensuring a more robust and reliable analysis than other analyses. In addition, the application of structural equation modeling to longitudinal studies may allow us to examine changes in the relationships between variables over time, which can be of great value in generating dynamic models of human behavior and social processes, in particular in the context of using telemedical applications.

Furthermore, a major general challenge was the great heterogeneity of the care facilities, in terms of both internal aspects (e.g., infrastructure, organization, hierarchy) and the basic motivation to participate. As a result, some nursing facilities were more involved in the empirical surveys than other nursing facilities, where in some cases there was no feedback at all. However, this was also reflected in the basic frequency of technology use: the nursing homes that did not take part in the empirical studies were also among those who had performed little to zero telemedical consultations. Here, it should be considered for future research that the current staffing shortages and high workload in care facilities present significant challenges to the feasibility of conducting empirical studies on a large scale. It is therefore essential to establish good communication and understanding of the care situation

from the outset, and to maintain consistent contact with the nursing homes involved and their management.

Last but not least, the COVID-19 pandemic was a major challenge for the implementation of empirical studies in the field, especially in the project years 2021 and 2022. Nevertheless, the close and constant consultation with the management of the nursing homes enabled individually tailored procedures in each case.

5. Conclusions

Our findings highlighted the significance and acceptance of integrating telemedicine in nursing homes to reduce unnecessary hospitalizations and support care personnel. Within the Optimal@NRW project, conducted in 24 nursing homes in Germany, we examined the acceptance of telemedicine in particular among care professionals. The results of the empirical studies presented here were of significant importance for the comprehension of telemedicine acceptance in nursing homes. Pre- and post-implementation evaluations were conducted from the perspective of care personnel working in geriatric care. This study demonstrated, for the specific case of geriatric care, that the acceptance of conducting telemedical consultations in the everyday life of nursing homes was overall positively evaluated. Furthermore, the results showed that perceived barriers decreased and were less relevant after using the telemedical consultations. These findings underscored the importance of tailoring communication and information about telemedicine to meet the needs and preferences of care personnel as a key user group.

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Informed Consent Statement: Informed consent was obtained from all participants involved in the studies.

Data Availability Statement: The data that support the findings of these studies are available from the author, (J.O.), upon reasonable request.

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References

1. Bao, J.; Chua, K.-C.; Prina, M.; Prince, M. Multimorbidity and care dependence in older adults: A longitudinal analysis of findings from the 10/66 study. *BMC Public Health* **2019**, *19*, 1–10. [CrossRef] [PubMed]
2. Dall, T.M.; Gallo, P.D.; Chakrabarti, R.; West, T.; Semilla, A.P.; Storm, M.V. An aging population and growing disease burden will require alarge and specialized health care workforce by 2025. *Health Aff.* **2013**, *32*, 2013–2020. [CrossRef] [PubMed]
3. Walker, A.; Maltby, T. Active ageing: A strategic policy solution to demographic ageing in the European Union. *Int. J. Soc. Welf.* **2012**, *21*, 117–130. [CrossRef]
4. Pickard, L. A growing care gap? The supply of unpaid care for older people by their adult children in England to 2032. *Ageing Soc.* **2015**, *35*, 96–123. [CrossRef]

5. Sundmacher, L.; Fischbach, D.; Schuettig, W.; Naumann, C.; Augustin, U.; Faisst, C. Which hospitalisations are ambulatory care-sensitive, to what degree, and how could the rates be reduced? Results of a group consensus study in Germany. *Health Policy* **2015**, *119*, 1415–1423. [CrossRef] [PubMed]
6. Ouslander, J.G.; Berenson, R.A. Reducing unnecessary hospitalizations of nursing home residents. *N. Engl. J. Med.* **2011**, *365*, 1165–1167. [CrossRef]
7. Jacobs, K.; Kuhlmey, A.; Greß, S.; Klauber, J.; Schwinger, A. *Pflege-Report 2018: Qualität in der Pflege*; Care Report 2018: Quality in Care; Springer Nature: Berlin, Germany, 2018; pp. 97–125.
8. Theou, O.; Squires, E.; Mallery, K.; Lee, J.S.; Fay, S.; Goldstein, J.; Armstrong, J.J.; Rockwood, K. What do we know about frailty in the acute care setting? A scoping review. *BMC Geriatr.* **2018**, *18*, 1–20. [CrossRef] [PubMed]
9. Kim, S.; Ko, S.-K.; Lee, T.Y.; Lee, J.-H. Potentially avoidable hospitalizations for older patients transferred from long-term care hospitals: A nationwide cross-sectional analysis of potential healthcare consequences. *Inter. Emerg. Med.* **2023**, *18*, 169–176. [CrossRef] [PubMed]
10. Wootton, R.; Craig, J.; Patterson, V. *Introduction to Telemedicine*; CRC Press: Boca Raton, FL, USA, 2017.
11. Cook, D.J.; Augusto, J.C.; Jakkula, V.R. Ambient intelligence: Technologies, applications, and opportunities. *Perv. Mob. Comput.* **2009**, *5*, 277–298. [CrossRef]
12. Al-Shorbaji, N. The World Health Assembly resolutions on eHealth: eHealth in support of universal health coverage. *Method. Inform. Med.* **2013**, *52*, 463–466. [CrossRef]
13. Elbaz, S.; Cinalioglu, K.; Sekhon, K.; Gruber, J.; Rigas, C.; Bodenstein, K.; Naghi, K.; Lavin, P.; Greenway, K.T.; Vahia, I. et al. A systematic review of telemedicine for older adults with dementia during COVID-19: An alternative to in-person health services? *Front. Neurol.* **2021**, *12*, 761965. [CrossRef]
14. Omboni, S.; Padwal, R.; Alessa, T.; Benczúr, B.; Green, B.B.; Hubbard, I.; Kario, K.; Khan, N.A.; Konradi, A.; Logan, A.G.; et al. The worldwide impact of telemedicine during COVID-19: Current evidence and recommendations for the future. *Connect Health* **2022**, *1*, 7–35. [CrossRef] [PubMed]
15. Harst, L.; Lantzsch, H.; Scheibe, M. Theories predicting end-user acceptance of telemedicine use: Systematic review. *J. Med. Int. Res.* **2019**, *21*, e13117. [CrossRef] [PubMed]
16. Amkreutz, J.; Lenssen, R.; Marx, G.; Deisz, R.; Eisert, A. Medication safety in a German telemedicine centre: Implementation of a telepharmaceutical expert consultation in addition to existing tele-intensive care unit services. *J. Telemed. Telecare* **2020**, *26*, 105–112. [CrossRef]
17. Felzen, M.; Beckers, S.K.; Kork, F.; Hirsch, F.; Bergrath, S.; Sommer, A.; Brokmann, J.C.; Czaplik, M.; Rossaint, R. Utilization, safety, and technical performance of a telemedicine system for prehospital emergency care: Observational study. *J. Med. Int. Res.* **2019**, *21*, e14907. [CrossRef]
18. Qi, W.; Ovur, S.E.; Li, Z.; Marzullo, A.; Song, R. Multi-sensor guided hand gesture recognition for a teleoperated robot using a recurrent neural network. *IEEE Robot. Autom. Lett.* **2021**, *6*, 6039–6045. [CrossRef]
19. Wang, F.; Chen, F.; Dong, Y.; Yong, Q.; Yang, X.; Zheng, L.; Su, H. Whole-Body Teleoperation Control of Dual-Arm Robot Using Sensor Fusion. *Biomimetics* **2023**, *8*, 591. [CrossRef] [PubMed]
20. Sabesan, S.; Kelly, J.; Evans, R.; Larkins, S. A tele-oncology model replacing face-to-face specialist cancer care: Perspectives of patients in North Queensland. *J. Telemed. Telecare* **2014**, *20*, 207–211. [CrossRef]
21. Barbosa, W.; Zhou, K.; Waddell, E.; Myers, T.; Dorsey, E.R. Improving access to care: Telemedicine across medical domains. *Annu. Rev. Public Health* **2021**, *42*, 463–481. [CrossRef]
22. Battineni, G.; Sagaro, G.G.; Chintalapudi, N.; Amenta, F. The benefits of telemedicine in personalized prevention of cardiovascular diseases (CVD): A systematic review. *J. Personal. Med.* **2021**, *11*, 658. [CrossRef]
23. Otto, L.; Harst, L. Investigating barriers for the implementation of telemedicine initiatives: A systematic review of reviews. In Proceedings of the Twenty-Fifth Americas Conference on Information Systems, Cancun, Mexico, 15–17 August 2019.
24. Muehlensiepen, F.; Knitza, J.; Marquardt, W.; May, S.; Krusche, M.; Hueber, A.; Schwarz, J.; Vuillerme, N.; Heinze, M.; Welcker, M. Opportunities and barriers of telemedicine in rheumatology: A participatory, mixed-methods study. *Int. J. Environ. Res. Public Health* **2021**, *18*, 13127. [CrossRef] [PubMed]
25. Keenan, A.J.; Tsourtos, G.; Tieman, J. The value of applying ethical principles in telehealth practices: Systematic review. *J. Med. Int. Res.* **2021**, *23*, e25698. [CrossRef] [PubMed]
26. Florez-Revuelta, F.; Mihailidis, A.; Ziefle, M.; Colonna, L.; Spinsante, S. Privacy-aware and acceptable lifelogging services for older and frail people: The PAAL project. In Proceedings of the IEEE 8th International Conference on Consumer Electronics, Berlin, Germany, 2–5 September 2018.
27. Ohligs, M.; Stocklassa, S.; Rossaint, R.; Czaplik, M.; Follmann, A. Employment of telemedicine in nursing homes: Clinical requirement analysis, system development and first test results. *Clin. Interv. Aging* **2020**, *15*, 1427–1437. [CrossRef] [PubMed]
28. Davis, F.D.; Bagozzi, R.P.; Warshaw, P.R. User acceptance of computer technology: A comparison of two theoretical models. *Manag. Sci.* **1989**, *35*, 982–1003. [CrossRef]
29. Venkatesh, V.; Morris, M.G.; Davis, G.B.; Davis, F.D. User acceptance of information technology: Toward a unified view. *MIS Q.* **2003**, *27*, 425–478. [CrossRef]
30. Rahimi, B.; Nadri, H.; Afshar, H.L.; Timpka, T. A systematic review of the technology acceptance model in health informatics. *Appl. Clin. Inform.* **2018**, *9*, 604–634. [CrossRef] [PubMed]

31. Peek, S.T.M.; Wouters, E.J.M.; Van Hoof, J.; Luijkx, K.G.; Boeije, H.R.; Vrijhoef, H.J.M. Factors influencing acceptance of technology for aging in place: A systematic review. *Int. J. Med. Inform.* **2014**, *83*, 235–248. [CrossRef] [PubMed]
32. Kamal, S.A.; Shafiq, M.; Kakria, P. Investigating acceptance of telemedicine services through an extended technology acceptance model (TAM). *Technol. Soc.* **2020**, *60*, 101212. [CrossRef]
33. Kissi, J.; Dai, B.; Dogbe, C.S.K.; Banahene, J.; Ernest, O. Predictive factors of physicians' satisfaction with telemedicine services acceptance. *Health Inform. J.* **2020**, *26*, 1866–1880. [CrossRef]
34. Alexandra, S.; Handayani, P.W.; Azzahro, F. Indonesian hospital telemedicine acceptance model: The influence of user behavior and technological dimensions. *Heliyon* **2021**, *7*, e08599. [CrossRef]
35. Ziefle, M.; Wilkowska, W. Technology acceptability for medical assistance. In Proceedings of the 4th International Conference on Pervasive Computing Technologies for Healthcare, Munich, Germany, 22–25 March 2010.
36. Offermann-van Heek, J.; Ziefle, M. They don't care about us! Care personnel's perspectives on ambient assisted living technology usage: Scenario-based survey study. *JMIR Rehab. Assist. Technol.* **2018**, *5*, e10424. [CrossRef] [PubMed]
37. Brücken, D.; Unterkofler, J.; Pauge, S.; Bienzeisler, J.; Hübel, C.; Zechbauer, S.; Rossaint, R.; Greiner, W.; Aufenberg, B.; Röhrig, R.; et al. Optimal@ NRW: Optimized acute care of nursing home residents using an intersectoral telemedical cooperation network—Study protocol for a stepped-wedge trial. *Trials* **2022**, *23*, 814. [CrossRef] [PubMed]
38. Offermann, J.; Wilkowska, W.; Schaar, A.K.; Brokmann, J.C.; Ziefle, M. Needs, Requirements, and Technology Acceptance using Telemedical Consultations in Acute Medical Situations in Nursing Homes. In Proceedings of the 8th International Conference on Information and Communication Technologies for Ageing Well and e-Health (ICT4AWE), Online, 23–25 April 2022; Scitepress: Setúbal, Portugal, 2022; pp. 105–116.
39. Cohen, J.; Cohen, P.; West, S.G.; Aiken, L.S. *Applied Multiple Correlation/Regression Analysis for the Behavioral Sciences*, 3rd ed.; Taylor & Francis: Oxfordshire, UK, 2003.