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Overcoming a Knowledge Gap of Healthcare Professionals: The Influence of Previous Experience on the (Non-)Adoption of VR in Medical Rehabilitation

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Submitted to: Journal of Medical Internet Research
on: June 08, 2024

Preprint
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Abstract

Background: The metaverse concept, gaining popularity since 2021, integrates technologies like virtual reality (VR) presenting novel opportunities for healthcare (HC). The use of VR technologies in HC, particularly in medical rehabilitation, has demonstrated effectiveness by enabling patient remobilization in virtual environments, offering real-time performance feedback, enhancing physical function and quality of life, and allowing patients to perform exercises autonomously. Nevertheless, integration of VR into routine rehabilitative practice is facing slow adoption due to concerns from HC professionals regarding data security and ethical considerations.

Objective: This study seeks to explore how previous experience with VR technologies influences HC professionals' decisions to adopt or reject these technologies in medical rehabilitation.

Methods: Using Rogers' diffusion of innovation theory, we conducted 23 semi-structured interviews with HC professionals from different rehabilitative fields in Germany. We grouped the interview participants regarding their innovativeness into VR experienced "innovators" and non-experienced "laggards". We apply qualitative content analysis techniques and categorize 26 adoption and rejection factors.

Results: The identified 26 factors influence VR technology adoption and rejection. VR-experienced "innovators" showed different adoption patterns compared to non-experienced "laggards", while factors of adoption hardly differed.

Conclusions: Addressing unique needs of both groups is crucial for wider VR acceptance in HC. The study enhances understanding of technology adoption, offering insights for developing strategies to improve VR integration in medical rehabilitation.

(JMIR Preprints 08/06/2024:62649)
DOI: https://doi.org/10.2196/preprints.62649

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Abstract

Background: The metaverse concept, which has been gaining popularity since 2021, integrates technologies like virtual reality (VR) and opens up new possibilities in healthcare (HC). VR technologies in HC, particularly in medical rehabilitation, have demonstrated effectiveness by enabling patient remobilization in virtual environments, offering real-time performance feedback, enhancing physical function and quality of life, and allowing patients to exercise autonomously. Nevertheless, integrating VR technologies into routine rehabilitative practice is facing slow adoption due to HC professionals' concerns regarding data security and ethical considerations.
Objective: This study seeks to explore how previous experience with VR technologies influences HC professionals' decisions to adopt or reject these technologies in medical rehabilitation.
Methods: We conducted 23 semi-structured interviews with HC professionals from different rehabilitative fields in Germany, which we grouped into VR experienced "innovators" and non-experienced "laggards" according to their innovativeness. When analyzing the interviews, we applied qualitative content analysis techniques and revealed 56 preliminary categories from the transcripts.
Results: We merged the preliminary categories into 26 adoption and rejection factors, drawing links to Rogers's diffusion of innovation theory (DOI). In addition to the pure identification of context-specific influencing factors, we were also able to identify differences between these factors concerning the two different user groups. VR-experienced "innovators" showed different adoption patterns than non-experienced "laggards", while adoption factors hardly differed. Thus, our results indicate that addressing the unique needs of both groups is crucial for wider VR acceptance in HC.
Conclusions: The study enhances a thorough understanding of the HC professionals' perspectives on the use of VR technology in medical rehabilitation and sets the foundation for successful widespread implementation. We contribute to the technology adoption and diffusion research stream and offer insights for developing strategies to improve VR integration in medical rehabilitation.

Keywords: Virtual Reality; Technology Adoption; Medical Rehabilitation; Qualitative Content Analysis; Adoption Decision Process; Healthcare Professionals; Previous Experience

Introduction

Overview

Today's technology has changed how people engage with their physical environment. Since 2021, the metaverse concept has gained significant international interest and has become a popular subject in the technology industry, where developers are actively working to bring this vision to life [1]. Integrating metaverse technologies into the healthcare (HC) sector has emerged as a revolutionary paradigm, presenting novel opportunities for patient care, medical research, and medical education [2]. Despite enthusiasm, much remains unknown about the metaverse. A general caution by HC professionals towards adopting (digital) innovations contributes to the slow diffusion of the metaverse in HC [3]. There are concerns about data security, technological interoperability, and ethical considerations [2].

In light of the growing general interest in the metaverse [4] and the evolving technological landscape within the HC sector, virtual reality (VR) is regaining popularity as a central building block of metaverse technology [5]. VR technologies afford users the ability to immerse themselves in immersive virtual environments. By utilizing headsets, smart glasses, and other devices, users enter a virtual realm wherein they can engage, communicate, and partake in diverse activities comparable to those in the physical world [6,7].

Studies have demonstrated the effectiveness of VR technologies in many areas of HC, such as psychiatry, surgery, teaching and training, and medical rehabilitation [8,9]. Further, VR technologies can be particularly suitable in medical rehabilitation, allowing patients to begin remobilization in a virtual world [10]. VR technology holds transformative potential, proving its superiority over traditional approaches [11,12]. Recent studies underscore the positive impact of VR technologies on physical function and overall quality of life in patients with diverse medical conditions [12,13]. VR-based medical rehabilitation offers real-time performance feedback, allowing post-session performance analysis [14]. Moreover, greater autonomy is seen as an added value of the technology, as it allows patients to perform exercises without close supervision by a therapist, reducing HC professionals' guidance [15].

Although the potential of VR technologies in medical rehabilitation is well-known and researched, the clinical adoption of these technologies remains low [16,17]. Some of these practical hurdles can be attributed to the negative effects of VR technologies, including motion sickness [18], ocular system overload [19], and decreased sense of presence [20]. (Potential) users also express challenges in introducing VR technologies, such as privacy and security concerns and concerns regarding the patient population [7].

To comprehend the reasons underlying the limited integration of VR technologies, it is imperative to delve into the perspectives of (potential) users [17,21]. Particularly in information systems, significant emphasis has been placed on understanding why users adopt or reject specific technologies [22].

The adoption of VR technologies in medical rehabilitation has already been studied. However, the studies either focus on a specific clinical condition, e.g., stroke [23,24], a specific medical rehabilitation area, e. g., communication rehabilitation [25,26], on a specific patient group, e. g., veterans [27] or on a specific group of HC professionals, e.g., speech-language pathologists [26]. Besides, the existing studies predominantly base their findings on statements about the hypothetical use of VR technologies in medical practice, as most of the study participants have not yet used VR technology in a professional context [25]. Thus, research is needed to comprehensively investigate the factors that influence the adoption of VR technology by HC professionals, not just without but especially with previous experience, as the call of research of Bryant et al. [25] recommends going beyond the hypothetical use of VR technologies. This investigation is paramount for discerning the determinants that prompted VR-experienced HC professionals ("innovators") to embrace VR technologies, in contrast to HC professionals without VR experience ("laggards"), who may exhibit resistance to digital innovations. Following this call for research, the study addresses the following research questions:

RQ. *How does previous experience with VR technologies influence HC professionals' decisions to adopt or reject these technologies in medical rehabilitation?*

We use the diffusion of innovation (DOI) theory by Rogers [28] as the theoretical lens for answering this research question, as it has already been shown to be useful in explaining the adoption of technology in the HC context [29,30]. This theory deals with innovation adoption and diffusion, differentiates between different types of adopters, and is, therefore, an appropriate framework for this paper. We apply this theory by conducting 23 semi-structured interviews with HC professionals with

and without previous experience with VR technology working in medical rehabilitation in Germany.

Virtual Reality in Medical Rehabilitation

Medical rehabilitation, which improves physical and mental functioning to reduce disability, is a core component of high-value care [31]. According to the World Health Organization [32], approximately 2.4 billion individuals worldwide live with conditions requiring medical rehabilitation. This number is expected to rise due to the demographic shift toward an older population with higher life expectancy [33]. Medical rehabilitation requires continuous monitoring, individualized treatment plans, adaptations to the patient's progress, and thus, it is very time-consuming and costly [34]. In light of the deteriorating conditions in the HC system, characterized by a rising demand for medical rehabilitation services coupled with a dwindling supply due to a shortage of HC professionals [35], there is a pressing need to explore innovative solutions.

The application of VR technologies in medical rehabilitation represents a promising innovative approach to explore novel ways for digitally augmented treatments and therapeutic processes that enable spatially and temporally independent treatments of patients while reducing the workload of HC professionals [36]. VR technologies allow users to immerse themselves in an artificial, computer-generated environment and experience it interactively. The user usually wears a headset that offers a 360-degree view of the virtual world and can control the environment with various input devices such as hand controllers or motion sensors [37]. Although definitions of VR are varied, there are three characteristics that most definitions agree on: interaction, imagination, and immersion [38]. Interactivity refers to the VR environment's responsiveness to user input. Imagination refers to the human ability to see non-existent objects, and immersion relates to the user's sense of being a part of the actions taking place in the virtual environment. VR provides the user with a completely virtual environment separate from the physical space, ranging from low immersion to full immersion [39].

Starting with gaming as one of the most popular applications for VR, in recent years, the use of VR technologies has spread to many other domains such as (medical) education [40], marketing [41], and HC [42]. Especially in the field of HC, the development of VR technologies and the exploration of possible application areas have progressed [17]. For example, studies have demonstrated the effectiveness of VR technologies in many areas of HC, such as psychiatry, surgery, teaching and training, telemedicine, and medical rehabilitation [8,9]. Considering VR technologies in medical rehabilitation, its application offers great advantages. The ability to simulate real-life situations visually and interactively can help improve the recovery of functions and abilities of patients [43]. For example, studies have indicated that VR-based medical rehabilitation can effectively treat patients with spinal cord injuries, Alzheimer's disease, brain injuries, and other conditions. In spinal cord injury rehabilitation, VR technologies have been investigated as a tool for gait training. Studies have shown that patients who received VR-based gait training significantly improved walking speed and distance compared to traditional gait training methods [44]. Besides these promising studies, several adverse effects of exposure to VR environments have been well-documented and may cause issues. Commonly cited are, for example, motion sickness [18], ocular system overload [19], decreased control of limbs and posture [45], decreased sense of presence [20], as well as the development of reactions inappropriate for the natural environment [46]. However, adverse effects such as motion sickness on the immediate user (e.g., patients) have been reduced to a minimum by advancing the technology development in recent years, leaving the adoption decision to the HC professionals (e.g., therapists) [47].

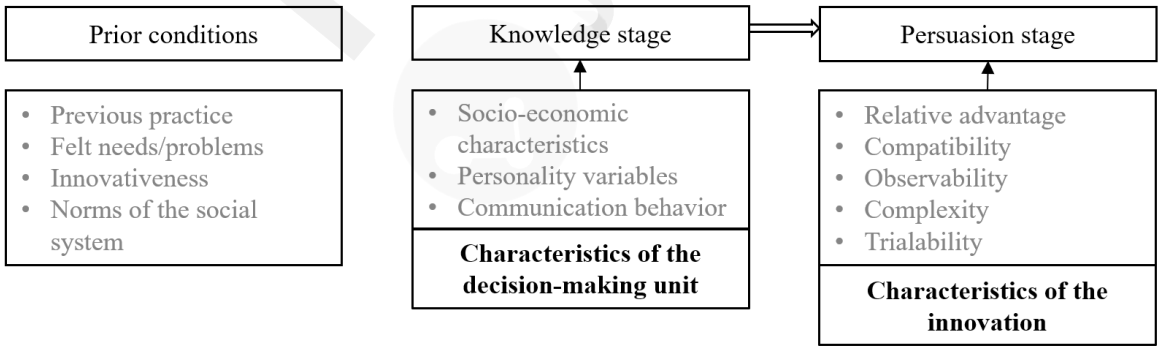
Users' Perception in VR-Diffusion

In the implementation and diffusion of (new) technologies, it is important to understand the user's perception of the technology. This is the starting point for diffusion, adoption, and acceptance

research, which are highly relevant for investigating the implementation of innovations (e.g., technologies) [48–50]. All three research directions place the concept of innovation, characterized by the concept-defining criterion of the novelty of a product, process, or technology, as the starting point in the center of interest. The most well-known and widely applied theories in this research area are the Technology Acceptance Model (TAM; [51]), the Unified Theory of Acceptance and Use of Technology (UTAUT; [52]), and the DOI theory. While TAM and UTAUT focus primarily on the individual user's intention regarding technology usage [51,52], the DOI theory not only considers the individual perspective on the adoption of the innovation but extends the consideration to the diffusion of the innovation in a social system [28]. Thus, the adoption decision process is seen as a micro viewpoint on change, whereas diffusion is a macro perspective that describes how innovation spreads throughout a population [28]. According to Rogers [28], the adoption decision process is embedded in the diffusion process, implying that if a critical mass of individuals adopts an innovation, it leads to the innovation's diffusion to the broader population.

Given the need to understand how individuals perceive innovation in our context, we focus on the micro level. We specifically examine prior conditions, knowledge, and the persuasion stage within the adoption decision process (see Figure 1). The adoption decision process that individuals go through when adopting innovation is preceded by the following prior conditions: *previous practice, perceived needs/problems*, *innovativeness*, and *the norms of the social system*. The first stage is about acquiring *knowledge* about the innovation and developing some understanding of how it works. Rogers [28] distinguishes between awareness knowledge (knowing an innovation exists), how-to knowledge (knowing how to use an innovation properly), and principles knowledge (knowing why an innovation works). According to Rogers [28], knowledge is determined by the individual's *socio-economic characteristics, personality variables, and communication behavior*. In stage two, *persuasion*, a positive or negative attitude regarding the innovation is created, determined by five key characteristics of innovation: *relative advantages, trialability, compatibility, complexity,* and *observability*. *Relative advantage* refers to the perceived benefits of an innovation. *Trialability* refers to the ability to test an innovation before committing to it. *Compatibility* refers to how well the innovation integrates with potential adopters' values and needs. *Complexity* measures how difficult an innovation is to understand, while *observability* is the visibility of the benefits of an innovation to potential adopters.

Figure 1. Prior conditions, knowledge stage, and persuasion stage within the adoption decision process (Rogers [28]).



To gain a better understanding of the diffusion of innovations from a macro perspective, it is essential to consider the diffusion within a social system comprising different adopter groups [28]. Rogers distinguishes between categories of adopters: innovators, early adopters, early majority, late majority, and laggards. This is important because not everyone possesses the same motivation to adopt new technologies. He categorizes the adopters based on innovativeness because innovativeness

helped in understanding the desired and main behavior in the adoption decision process. For Rogers [28], innovators are prepared to experience new ideas and have complex technical knowledge. Compared to innovators, early adopters are more limited by the boundaries of the social system. The attitudes of early adopters towards innovation are more important as role models. Rogers [28] assumed that although the early majority interact well with other members of the social system, they do not have the leadership role that the early adopters have. Similar to the early majority, the late majority comprises members of the social system who wait until most of their peers adopt the innovation. Although they are skeptical about the innovation and its outcomes, economic necessity and peer pressure may persuade them to adopt the innovation. As Rogers [28] found, the laggards have a traditional view and are more skeptical of innovation and change.

Methods

A qualitative research approach is suitable for understanding and investigating HC professionals' non(adoption) in medical rehabilitation, going beyond simplified factors of existing adoption theories [53,54]. Utilizing interviews, we aim to ascertain the prevalent experiences, viewpoints, and emotions held by the two groups of HC professionals regarding VR technologies in medical rehabilitation.

Interview Guideline

The interview guideline was developed using Castillo-Montoya's [55] four-phase framework for refining interview protocols. In the first phase, we mapped the interview questions onto the research question to ensure alignment. Following this, we revised our interview guideline to include practical terms that correspond to the interviewees' terminology (e.g., "use" instead of "adoption") (phase 2). In phase 3, we reflectively discussed and revised the first version of the interview guideline and created two versions (one for participants with and one for participants without VR experience). The people with VR experience were asked about their experiences, while a specific use case was created for people without VR experience, like "Imagine you are using VR […]". During phase 4, the interview guidelines underwent pretesting with a prospective doctor and a physical therapist. The final interview guidelines structured the interviews as follows: At the beginning of each interview, we gave a short overview of the research team and the aim of the study before requesting the interviewees to introduce themselves and their professional backgrounds. After establishing a comfortable atmosphere for discussion, we questioned the interviewees about VR technologies in their field of medical rehabilitation. We used open-ended questions to avoid biasing respondents in any direction and to preserve the study's exploratory nature [55]. The questions were of the following type: "*When you think of VR technologies, what are the first thoughts that come to your mind?";" What is your take on the use of VR technologies in rehabilitation?".* With the participants' agreement, audio recording and transcription were carried out to conduct a full data analysis using MAXQDA. To ensure the confidentiality and privacy of the participants, all personal data collected during the study were pseudonymized.

Data Analysis

For the analysis of interview transcripts, we followed Mayrings' recommendations for mixed inductive and deductive category building using qualitative content analysis (QCA)[56]. We started with the inductive, data-driven development of categories and set two requirements for these categories. First, based on the research question, the categories should include factors that affect the adoption decision process of VR technologies in medical rehabilitation. The second requirement concerns the abstraction level of the concepts [56]. To achieve a certain degree of transferability of the results, the categories aim to include content that is not unique to the interview participant but is also transferable to other individuals [57]. After formulating these requirements, the interview

transcripts were analyzed by building inductive categories. First, we created 56 preliminary categories and recorded relevant information in memos. To place the identified categories in an appropriate context, we additionally coded statements from the interviewees regarding their understanding and experience of VR technologies and their perceived prevalence and future importance in medical rehabilitation. After reviewing 38% of the material, Mayring [56] recommends a revision after 10-50% of the data. The authors discussed the memos and categories, merged analogous categories, and resolved conflicting categories. This approach led the authors to draw links to the adoption decision process of DOI theory, enabling the use of DOI-based categories for the deductive coding process. Subsequently, we applied deductive codes to all the interview transcripts. Finally, the preliminary categories were subsumed into 26 factors and assigned four categories.

Results

Descriptive Results and Study Population

We conducted expert interviews in Germany from February to April 2023. To ensure diverse perspectives, medical rehabilitation experts with different experiences with VR technologies, professional backgrounds, genders, and ages were included. Finally, we interviewed 23 participants out of 36 contacted HC professionals, comprising physiotherapists (n=8), doctors (n=4), sports therapists (n=3), occupational therapists (n=2), nurses (n=2), speech and language therapist (n=1), osteopath (n=1), psychologist (n=1) and medical technical functional diagnostician (n=1). The interviews lasted about 30 minutes on average, and a total of 627 interview minutes were included in the data analysis. The characteristics of the interviewees and their VR experience are listed in Table 1.

Table 1. Descriptive characteristics of the interviewees (n=23)

ID	Gender	Age	Medical professional	VR experience
PT1	Male	25	Physiotherapist	None
PT2	Male	34	Physiotherapist	None (private)[a]
PT3	Male	30	Physiotherapist	Yes (professional)[b]
PT4	Female	26	Physiotherapist	None
PT5	Female	50	Physiotherapist	None
PT6	Male	25	Physiotherapist	None
PT7	Female	26	Physiotherapist	Yes (professional)
PT8	Male	36	Physiotherapist	Yes (professional)
D1	Male	33	Doctor	None
D2	Female	27	Doctor	None
D3	Male	63	Doctor	Yes (professional)
D4	Male	45	Doctor	None
ST1	Male	33	Sports therapist	None
ST2	Female	30	Sports therapist	Yes (professional)
ST3	Male	36	Sports therapist	Yes (professional)
OT1	Female	37	Occupational therapist	Yes (professional)
OT2	Female	32	Occupational therapist	Yes (professional)
N1	Male	46	Nurse	Yes (professional)
N2	Female	44	Nurse	Yes (professional)
LT1	Female	36	Speech and language therapist	None
O1	Male	58	Osteopath	Yes (professional)

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P1	Female	32	Psychologist		Yes (professional)
MTF1	Female	30	Medical-technical diagnostician	functional	None (private)
PT1	Male	25	Physiotherapist		None

[a]In the context of gaming.
[b]In the context of occupation.

Coding Results

Aligned with our research goal, we explored factors influencing HC professionals' (non)adoption of VR technologies in medical rehabilitation. In the following section, we present our findings of the QCA and support them with interview quotes. First, we introduce the interviewees' experience and understanding of VR technologies. Following, we describe the four categories and 26 factors that determine VR adoption or rejection by HC professionals in medical rehabilitation. To deeply analyze the influencing factors on the adoption decision, the interview participants were categorized into two groups based on whether they had professional (p) or no professional (np) experience with VR technologies (see Table 1). In the section 'Previous Practice,' further reference is made to the subdivision.

All participants are aware of the existence of VR technologies and have some understanding of how these technologies work, although not all participants had concrete experience with the technology. Overall, nine of the participants had no previous experience with VR technologies. In contrast, two participants had experience exclusively in a private context, and twelve participants reported experience with VR technologies in their profession. Despite a basic understanding of VR technologies, some interviewees could not imagine what VR technologies meant in medical rehabilitation. For example, one interviewee (PT4; np) commented: *"Yes. So, as I said, I cannot imagine anything about how the whole thing [VR technologies] is supposed to work […]."* Further, another participant (PT5; np) stated: *"I cannot imagine how you could do something rehabilitative for the patient [with VR technologies]."* Besides this lack of understanding, HC professionals sometimes misunderstand VR technologies in medical rehabilitation because the "difference between therapy and game" (OT2; p) is unclear. All participants considered the prevalence of VR technologies in medical rehabilitation in Germany low. One interviewee said (MTF1; np): *"I would say it [VR technologies' prevalence] is very low. Are there any [VR technologies] at all? Well, some pioneers are probably already working with it [VR technologies]. But that is probably really the minority […]."* In contrast, VR technologies are already being used more frequently in other countries, such as Japan (P1; p). In general, most participants were in favor of the future relevance of VR technologies in medical rehabilitation even though they assume that the diffusion of VR technologies will take a while (MTF1; np).

Prior Conditions

The adoption decision process of the DOI theory is determined by the "prior conditions" and includes categories such as previous VR practices or norms of the social system. Table 2 provides an overview of the factors in medical rehabilitation identified through QCA, along with the number of text segments coded for each factor per experience group.

Table 2. Results of the prior conditions.

Prior conditions	Factors in medical rehabilitation	# coded text segments
Previous practices	No previous VR experience	Prof. experience: 0 No experience: 11

	Previous VR experience	Prof. experience: 12 No experience: 0
Norms of the social system	Patient perspective	Prof. experience: 45 No experience: 47
	Exchange in the team	Prof. experience: 6 No experience: 3
	External stakeholder	Prof. experience: 52 No experience: 39
Felt needs/problems	HC market uncertainties	Prof. experience: 9 No experience: 10
	(IT) infrastructure	Prof. experience: 22 No experience: 9
Innovativeness	HC professionals engagement	Prof. experience: 18 No experience: 16
	Low affinity with technology	Prof. experience: 15 No experience: 12

Previous Practice. We used this factor to categorize the interview participants according to their previous VR experience. As shown in Table 2, among the interviewees, eleven participants had no professional VR experience; however, among them, two individuals had previous private (gaming) experiences with VR technologies. Interviewees who had already been exposed to VR technologies in a private context recognized the potential of these technologies for their profession. For instance, one interviewee (OT2; p) commented: "*I put on [VR] glasses in a museum [...] and [then very quickly] this therapeutic idea was born in me."* Another participant (D3; p) stated: *"[I was once in] an exhibition of, I think it was Daimler [...], and I found that very fascinating. [...] [Shortly after that] I witnessed a startup, and that is when I got a real insight into what potential VR technologies have in rehabilitation.*" On the other hand, interviewees with no VR experience tend to express themselves in a rather anxious and reserved manner, such as interviewee PT4 (np): *"[...] I will be honest. I have a lot of respect for it [VR technologies]. But I have not had that experience with it [VR technologies], so I could say that it catches me or that I cannot do anything with it*." The other interview group, comprising twelve participants, has already gained VR experience in a professional context, ranging from at least once to daily.

Norms of the social system. This category refers to three stakeholders within the HC professionals' environment that influence their adoption decision: patients (92 coded segments), team of the HC professionals (9 coded segments), and the outer setting, like health insurance companies, legislation, and the organization the HC professionals work in (91 coded segments). Regarding **patients' characteristics,** interviewee D2 (np) stated: "*Maybe It [VR technologies] could fail in the sense that patients do not accept it, that they just say that it does not do anything for me or that confuses me, or I do not know how to do it right there.*" MTF1 (np) considers it important to bring the technology closer to the patient: *"[...] if you explain it [VR technologies] to them well and make it palatable, […] I do not think [patients] are then averse to it.*" Interviewee OT2 (p) asserted that patients listen to the therapist's recommendation: *"[…] I notice that so clearly. They [patients] are open to it. If I sit in front of them and say we are doing therapy today with VR technologies, and it can be an 80-year-old grandma, she does not say no […].*" Regarding the age of patients, VR users held a different view than non-VR users. ST2 (p) said she *"would not see it [age] as a barrier, but rather as an opportunity."* Interviewee T1 (np) could envision the use of VR technologies among certain age groups to a lesser extent: *"those who are not so technically skilled [...] so with over-60s, over-70s, over-80s."* Regarding the HC professional's **team** ST3 (p) noted that a new technology affine colleague introduced VR glasses to the team, and it "*is only a matter of time [before] VR glasses are*

in our house too." Some respondents indicated that they involved their team in the adoption decision, like OT1 (p): *"I always present such newer things to the team [and] the decision is then also [made] in the team."* The interviews revealed the **external stakeholder** in the context of the adoption decision of HC professionals. VR-experienced HC professionals have already actively explored financing options, particularly through health insurance companies, and have also dealt with the legal aspects. Interviewees agreed that financial support from health insurers may be key to VR adoption. One interviewee (ST2; p) commented: "*Otherwise, we would have made the investment [in VR technologies] a long time ago.*" In addition, HC professionals called for anchoring in therapeutic guidelines and recommendations, such as the S3 guideline, to decide which VR technologies they should use in practice (ST2; p). VR technologies must first be approved for medical purposes. One participant (P1; p) cited complexities related to Medical Device Regulation to bring VR technologies to market as medical devices. One respondent abdicated responsibility to the employer (organization) when asked why she was not yet using VR technologies: *"[it] was also not yet required [from the clinic] to be done that way*" (ST1; np). Participant D3 (p) hoped to see an increase in innovation in the organizations: "*Who is sitting there in the rehabilitation clinics with an open mind? [...] and how open is the [CEO] really to innovation?"* The interviewees often attribute decision-making power to the practice owner or management. Nevertheless, they see themselves as responsible for recommending VR technologies to top management and convincing them of their potential benefits (ST1; np).

Felt needs or problems. HC professionals cited **market uncertainties** 19 times in the interviews as factors that influence their adoption decisions independent of their VR experience. Interviewee D2 (np) sees VR technologies as a tool for the future to meet the requirements of the circumstances by saying: "*Well, in principle, it [VR technologies] will already play an important role because simply the demand for rehabilitation is growing, because the population is getting older. [...] But there will also be fewer specialists. Then you must look for alternatives to somehow maintain the rehabilitation programs without worsening the outcome or just not achieving it* […]." The growing shortage of HC professionals makes it necessary to stand out from the competition in finding new employees. Participant PT7 (p) is certain that VR technologies make this possible: "*We wanted to remain competitive (.) as a unique selling point. […] Of course, it is also special when I am looking for an employee and have VR glasses there."* Another factor influencing the adoption decision of VR technologies is the **(IT) infrastructure** in HC professional facilities, appearing 31 times in the interviews. One interviewee titled it "*a big barrier overall is implementing it [VR technologies] into existing structures because they have to be flexible and kind of make room*" (D3; p). In particular, the "*spatial requirements*" (ST1; np) would also have to be created. Participant PT8 (p) stated that *"[the] integration of VR technologies should result in an overall concept"*.

Innovativeness. The **engagement** of the HC professionals in the adoption of technological innovations such as VR in clinical and therapeutical work is thematized in 34 interview quotes. The ability of HC professionals to innovate in the use of VR technologies is a crucial aspect, as they *"[...] also have to look for themselves what they feel comfortable with [...] [so that] self-interest develops"* (ST3; p). Some interview participants saw the *"lack of motivation [...] as the biggest barrier"* (D3; p) to the adoption of VR technologies. One interviewee said: *"So, I am open to that kind of stuff [VR* technologies*]. I also like to deal with such things [VR* technologies*]. I think it [VR* technologies*] are totally cool"* (PT7; p) while another interviewee mentioned: *"So, I do not see why I should use it [VR* technologies*] now"* (PT6; np). The **affinity for VR technologies** emerged 27 times as an influential factor in HC professionals' adoption decisions. One interviewee (PT8; p) cited his staff's fears regarding their IT competencies during the VR adoption phase: "*There was a lot of fear: Oh God, so much technology. I cannot do this anyway. It is just too technically demanding for me. I am already overwhelmed if I have to kind of reset my laptop at home or run a virus program on it. [...] It took a*

while for them to accept that it is not that bad […]." In addition, interviewee LT1 (np) explained that her reluctance to use IT prevents her from doing so: *"I sometimes have a hard time with the latest innovations and with technology in general. That is why it takes me a little longer [and] when I can, I like to skip things like [VR technologies]."*

Characteristics of Healthcare Professionals

The characteristics of the decision-making unit are crucial when it comes to a person passing from the stage of knowledge to the stage of persuasion [28] This aspect comprises three main categories within the DOI: socio-economic characteristics, personality variables, and communication behavior (Table 3).

Table 3. Results of the characteristics of healthcare professionals.

Characteristics of the decision-making unit	Factors in medical rehabilitation	# coded text segments
Socio-economic characteristics	High average age	Prof. experience: 0 No experience: 5
Personality variables	/	/
Communication behavior	VR-related interaction patterns	Prof. experience: 11 No experience: 6

Interviewees disagreed about whether **high average age** as a socio-economic characteristic plays a role in adopting VR technologies. This factor was addressed a total of 11 times. One interviewee (P1; p) said the following: *"[…] and my own experience is that older therapists [are] not so good with technology."* An older participant explained, *"These technical things, that is what my daughter [as a physiotherapist] does a lot, and [if it does not work right away] then I lack access, and I just leave it"* (PT5; np). In contrast, interviewee ST1 (np) held a diverging opinion: *"There are definitely therapists, doctors, and colleagues in middle age or older who receive technology enthusiastically and also pass it on."* The interview data did not allow for interpretation regarding the personality variables, which are reportedly challenging to identify [28]. The **VR-related interaction patterns**, which describe how individuals communicate with each other, particularly concerning the dissemination of technologies like VR thematized in 17 interview quotes. HC professionals with VR experience have gained access to VR through testing it in seminars and social media. Furthermore, individuals from the group of HC professionals with VR experience express themselves as opinion leaders: "*I scheduled an appointment today at the school [...] VR and neurofeedback will be one of the main points I introduce there."* (OT2; p).

Knowledge of Healthcare Professionals

Based on the results of the interviews and in accordance with Rogers [28], we categorize knowledge into three types: awareness-knowledge, principles-knowledge, and how-to-knowledge. Table 4 provides an overview of the factors identified.

Table 4. Results of the knowledge of healthcare professionals.

Characteristics of the decision-making unit	Factors in medical rehabilitation	# coded text segments
Awareness-knowledge	Awareness-knowledge	Prof. experience: 8

		No experience: 8
Principles-knowledge	Principles-knowledge	Prof. experience: 4
		No experience: 0
How-to-knowledge	How-to-knowledge	Prof. experience: 22
		No experience: 15

Firstly, there is the **awareness-knowledge** of the existence of an innovation, which was addressed 16 times in the interviews. Secondly, there is **principles-knowledge** about how and why the innovation works, which was only mentioned a total of four times in the interviews and only among individuals who had experience with VR technologies. Thirdly, knowledge enables the correct application of an innovation (**how-to-knowledge**), which was discussed 37 times. Especially interviewees with VR experience indicated a lack of knowledge by HC professionals about the existence of VR technologies in medical rehabilitation. For instance, interviewee ST2 (p) mentioned: *"My father [as a physiotherapist] also said […] he would never have thought of getting something like that because he does not know it [VR technologies]."* Another interviewee (D3; p) noted that *"a lack of being informed about it [VR technologies]"* can be considered one of the *"biggest obstacles [to successful adoption]."* This missing knowledge should be addressed by more *"clearing-up work"* (OT2; p) in schools, in education, at therapy fairs, as well as an *"intensified medium appearance […] in the sense of television contributions"* (ST2; p) or *"rehabilitation magazines"* (D3; p). HC professionals with VR experience mentioned the appropriate use of innovation as an important adoption factor. To be able to use VR technologies properly therapeutically, "*education"* (e.g., OT2; p) and *"training courses"* (e.g., PT7; p, OT1; p) were most relevant to VR-experienced interviewees. Marketing activities, such as those on social media, at trade shows, or other events, can help raise awareness of the benefits and applications of VR technologies. Conversely, respondents with no VR experience emphasize the need for leadership initiatives from senior individuals and rehabilitation institutions to promote the awareness and adoption of such technologies. They advocate for top-down VR promotion, hoping that leaders and institutions in rehabilitation will actively drive these innovations forward and serve as role models.

Characteristics of VR Technologies

The adoption of an innovation is typically influenced by the perceived "characteristics of the innovation," including relative advantage, complexity, trialability, observability, and compatibility [28]. Table 5 provides an overview of the arrangement of these factors in medical rehabilitation as well as their frequency of occurrence in our interviews.

Table 5. Results of the characteristics of VR technologies.

Characteristics of the innovation	Factors in medical rehabilitation	# coded text segments
Relative Advantage	Effectiveness	Prof. experience: 84
		No experience: 53
	Efficiency	Prof. experience: 37
		No experience: 34
	Diversification	Prof. experience: 20
		No experience: 39
	Affordability	Prof. experience: 25
		No experience: 26
	Data security	Prof. experience: 4
		No experience: 8

Complexity	Complexity of VR hardware	Prof. experience: 13 No experience: 9
	Complexity of VR software	Prof. experience: 24 No experience: 25
Trialability	Trialability	Prof. experience: 7 No experience: 5
Observability	Lack of evidence-based studies	Prof. experience: 9 No experience: 6
	Measurability of results with VR technologies	Prof. experience: 15 No experience: 5
Compatibility	Compatibility with existing values and needs of HC professionals	Prof. experience: 27 No experience: 22
	Compatibility with existing IT systems	Prof. experience: 4 No experience: 5

Relative Advantage. The relative advantage is found in a total of 330 text passages in the interviews, divided into effectiveness with 137 coded text segments, efficiency with 71 coded text segments, diversification with 59 text segments, affordability with 51 coded text segments, and data security with 12 coded text segments.

The **effectiveness** was discussed by HC professionals with VR experience, with 84 coded text segments, compared to those without VR experience, which was 53 times, but for almost all respondents, the effectiveness achieved with VR technologies is an important indicator for the adoption or rejection of the technology. For example, one interviewee (PT3; p) said: *"But if […] the success that is achieved is not as great as if I were practicing with the patient in real-time. Then that would be again rather against the use of the VR technologies."* For respondents, a better outcome is conditioned by a *"higher motivation of the patient*" (e.g., ST3; p, D1; np, ST1; np), an *"increased self-efficacy*" (D3; p), an *"increased compliance"* (ST1; np), the *"distraction from the disease"* (PT1; np), and the *"closeness to everyday life"* (e.g., P1; p, OT1; p). Further, interviewees also questioned if the side effects of VR technology usage would have an impact on the effectiveness of the therapy, for example, *"additional screen time"*, the risk of *"various children and adolescents becoming addicted*," and the *"body awareness is lost"* (ST1; np). Respondents who were already using VR technologies mentioned side effects such as *"headaches"* (OT2; p), PT7, p), *"eye pain"* (PT; p), *"nausea"* (OT2; p), *"dizziness"* (PT7; p) and the risk of *"motion sickness"* (OT1; p, PT3; p). **Efficacy** encompasses statements about working faster (e.g., time efficiency), conserving resources (e.g., group therapy), and operating more economically (e.g., cost-benefit ratio) with VR technologies. The factor is addressed by HC professionals with VR experience 37 times and without VR experience 34 times. They differ in terms of perceived opportunities or concerns among HC professionals. On the one hand, individuals with no VR experience express concerns regarding training time/effort. The introductory phase of VR technologies "*seems to initially involve more work*" (LT1; np). Interviewee D2 (np) stated: "*The time investment required to engage with the technology is a tragic hurdle.*" On the other hand, those with VR experience discuss a temporal relief in their work. They expressed a desire for "*time savings*" (e.g., PT3; p) resulting from "*autonomous patient therapy from home without supervision*" (ST1; p), the possibility of "*group therapy*" (PT7; p), and "*automated documentation and measurement*" (PT7; p). **Diversification** encompasses statements regarding portfolio expansion through the integration of VR technologies. Portfolio expansion entails the augmentation of conventional therapeutic interventions through technologies such as VR. This factor is more frequently addressed by individuals without VR experience, with 39 coded text segments, compared to those with VR experience, which was mentioned in 20 instances. In terms of content,

the interviewees agreed that the technology acts as a *"support"* (e.g., D4; np), PT5; np). One participant (OT1; p) said: *"It [VR technologies] makes me more competent as a therapist."* Nevertheless, she would never let *"[VR technologies] stand alone as a base"* (OT1; p). Further, we understand diversification to mean individualized and patient-centered therapy, which respondents perceived as important. Interviewee PT6 (np) described: *"It [VR technologies] should be applicable to many patients, but still customizable. It should be for any age, for anybody constitution, or even for athletes, non-athletes, injuries, neurological, orthopedic […] there should be enough programs that can then be used."* Furthermore, MTF1 (np) described, *"[...] that it [VR technologies] should be personalized for the patient, that you can maybe create a familiar environment because it is always a more comfortable feeling for the patient than something foreign."* **Affordability** is addressed with comparable frequency among HC professionals, both with and without VR experience, mentioned 25 and 26 times, respectively. However, there are distinctions in their perceptions of costs. While predominantly HC professionals who did not use VR technologies assessed the cost as still *"very dauntingly high"* (PT1; np), one VR user who had already invested in the technology assessed the actual cost as not too high. In doing so, OT2 (p) described the investment in VR technologies as *"one of the smallest investments [made] here in practice compared to other therapy methods."* In addition to pure acquisition costs, concerns were also raised about *"development costs"* (ST1; np, PT3; p) and the potential cost of *"spare parts"* (ST1; np). With the help of *"leasing options"* (ST2; p, OT1; p), the cost risk of VR technologies could be mitigated. **Data security** is addressed by participants with VR experience four times, while those without VR experience discuss it twice as frequently. Overall, the interview participants hold differing opinions on this matter. For example, one interviewee (D2; np) without VR experience said the following: *"As soon as anything is digitally innovative, [data security] always comes right to my mind."* For one respondent with VR experience, data security played a rather subordinate role. Participant PT3 (p) reasoned: *"But when I say I always turn on the [VR] device and it does not store any data. I do not have to enter a name, [...] just button up and go. Then I do not think that is problematic [in terms of privacy]."* Furthermore, MTF1 (np) said that *"nowadays [...] data privacy must be accepted everywhere. That should be the lesser inconvenience."*

Complexity. Complexity as a characteristic of the innovation is found in a total of 71 text passages in the interviews, divided into the **complexity of VR hardware** with 22 coded text segments, and the **complexity of VR software** with 49 text segments. HC professionals with or without VR experience do not differ in terms of the mere frequency of mentioning this criterion. However, individuals with VR experience are more likely to assess what may be disruptive about the hardware (e.g., excessively heavy goggles). Participants describe that VR technology should be user-friendly, intuitive, and robust against user error (e.g., OT1; p). VR technologies should be designed to be simple enough *"[...] that if you are not that computer literate, you can get on with it quickly […]"* (LT1; np). One interviewee (PT2; np) stated that too much complexity in the system *"can lead to failure [of VR technologies]."* Further, interview participants indicated that lack of functionality and applicability impact usability the most. For example, one participant (PT3; p) explained: *"My biggest concern is the applicability, whether this concept works well or still seems very, very beginning. […] [then it may be] I bought it [VR technologies] but will never use it."* Besides the hardware quality, respondents ranked the software quality of VR technologies as important for potential adoption (e.g., PT2; n). The VR technologies should be "*transportable"* (OT2; p, LT1; np), *"light"* (OT2; p), *"comfortable"* (P1; p), and *"robust"* (ST1; np). Those interviewees who were already VR users criticized that the VR glasses are *"too heavy"* (P1; p, ST2; p), *"the cables [...] [can] be a difficulty"* (P1; p), and some glasses *"hurt on the nose"* (P1; p). Furthermore, P1 (p) found the use of VR glasses uncomfortable when the *"field of view [is] still very limited […] and partly a bit blurry".*

Trialability. The trialability of technologies played a minor role in the interviews. It was mentioned a

total of 12 times. Generally, individuals without VR experience expressed a desire to trial the technology beforehand. Interview participant D4 (np) expressed the following desire *"It would be good to test it [VR technology] beforehand. So that you know what you're dealing with […]. So do I really want to use it?".*

Observability. By observability, we mean the proof of the results through evidence-based studies and the measurability of the results of VR technologies. Observability is found in a total of 35 text passages in the interviews, divided into the **lack of evidence-based studies** with 15 coded text segments and the **measurability of results with VR technologies** with 20 text segments. Respondents who do not use VR technologies professionally primarily lacked studies on the evidence base (e.g., D2; np, LT1; np). Participant LT1 (np) stated that "*they [VR* technologies*] are not researched or proven with studies at all how much this does."* In contrast, the interviewees who use VR technologies commented that *"results can be seen directly"* (PT7; p), in that *"[the patients'] progress can be better displayed, and thus there is always a direct comparative control"* (OT1; p). One participant (PT7; p) added: *"[...] range of motion, mobility [...] you can measure it very well."* Individuals with VR experience emphasized the significant advantage of measurable and comparable outcomes facilitated by VR. Conversely, individuals without VR experience expressed a desire for precisely this effect.

Compatibility. Compatibility is found in a total of 58 text passages in the interviews. We understand compatibility ambiguously. On the one hand, compatibility is the extent to which VR technologies match the **existing values and needs of the HC professional** with 49 coded text segments. On the other hand, compatibility means the **interoperability and connectivity between technologies** with nine coded text segments. Concerning the former definition, the most common concern was about changed therapist-patient relationships due to VR technologies. Interviewees MTF1 (np) and ST2 (p) expressed the wish that therapy should continue to be *"person to person [...] so that the social component is not missing"*. Individuals without VR experience fear of being replaced. In addition to compatibility with existing values and norms, interview participants cited concerns about poor interoperability of the VR system and other equipment at the facility (e.g., PT2; np, D3; p). As PT2 (np) expressed: *"Maybe it also fails because of [lack of] connectivity."* He expressed the desire that VR technologies *"[should] be compatible with other devices."* Interviewee D3 (p) added: *"And then maybe it would be great if the VR medicine platform synchronizes as much as possible and does not have twelve operating systems."*

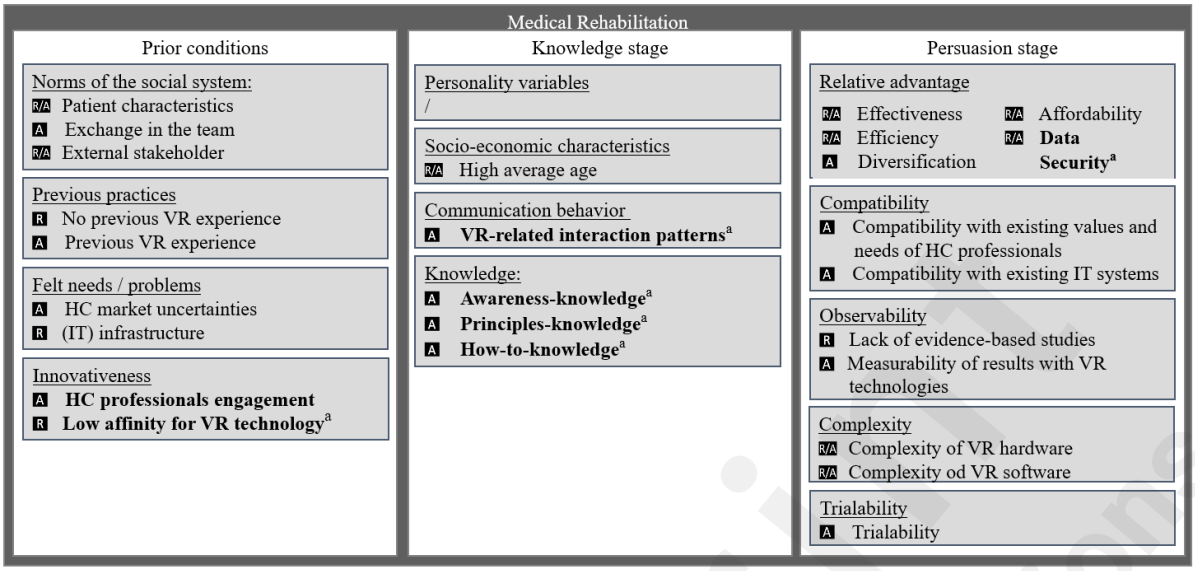
Discussion

Key Findings

This paper identified 26 factors that determine HC professionals' non(adoption) of VR technologies in medical rehabilitation (see Figure 2). To achieve this goal, this study examined the attitudes of HC professionals with and without VR experience to gain a nuanced understanding of the diffusion of VR technologies in medical rehabilitation. This, in turn, aims to enhance the overall understanding of the slow diffusion of innovations in HC. To this end, we followed Rogers' [28] adopter categorization, classifying HC professionals into VR-experienced "innovators" and non-experienced "laggards."

First, we discuss the characteristics of both groups. We then illustrate how these insights necessitate contextualizing the adoption decision process, as Rogers [28] outlined, for VR technologies in medical rehabilitation. This involves considering the similarities and differences among two adopter groups to improve the overall understanding of innovation dissemination in HC (see Figure 2 headings in bold).

Figure 2. Contributing factors to resistance and adoption of VR technologies in medical rehabilitation (R – Resistance, A – Adoption).



[a]Variations between VR-experienced "innovators" and non-experienced "laggards".

Characteristics of VR-experienced "innovators" and non-experienced "laggards".
We found evidence in our data supporting the characteristics of Roger's [28] generalized adopter categories in the DOI. HC professionals with VR experience exhibit a notable openness to VR technology and a great ability to deal with uncertainty related to the relatively new therapeutical option.

Participants with VR experience tried to develop strategies for potential problems (e.g., technical failure) and thus expressed solution-oriented thoughts on VR implementation such as training courses to deal with new technologies or the dissemination of knowledge through more educational work already in training, but also in the form of marketing campaigns. Such a solution-focused stance is typical of innovators, as conceptualized in the DOI, demonstrated by a study of Haun et al. [58] in the HC sector on the adoption of video consultations by general practitioners. Another characteristic that, according to the DOI, is related to the ability to innovate is the opinion leadership of innovators. One therapist, for example, reports using VR technologies at school to raise awareness.

HC professionals without VR experiences in our sample anticipated several problems, e.g., concerns regarding familiarization time/training effort due to the introduction of new technologies. They did not mention any possible solutions to their concerns. While non-VR users expressed criticism towards the outdated curriculum and therapy methods, their inclination towards embracing change appeared limited. The interviews elucidated that participants without VR experience tend to conform to existing practices rather than engage in forward-thinking innovation, indicating an indirect demand that managers set an example in the use of technologies such as VR. Respondents without VR experience even expect knowledge transfer of technologies such as VR by managers and rehabilitation organizations (top-down-push).

The results reveal more than just differences between the two adopter groups. Surprisingly, the respondents agreed on the factors that promote the adoption of VR technologies. For example, both groups cited the efficient use of technology or the measurability of therapy outcomes as promoting

factors. Respondents without VR experience often wanted the same factors that respondents with VR experience mentioned as major advantages when using the technology. This makes it clear that the advantages of VR technologies over conventional therapy methods in medical rehabilitation are not just utopian dreams but are being realized in practice.

These findings suggest that in implementation and dissemination efforts, HC professionals' concerns over perceived negative aspects of VR (e.g., cost and training effort) need to be addressed while specifically promoting positive aspects (e.g., working faster and time efficiency) may be of lesser importance since these are likely self-apparent to practicing HC professionals.

Fear of the new/Lack of knowledge.

In the HC sector, innovation diffusion unfolds fundamentally slower than in other sectors [59]. HC professionals are more deeply engaged in their clinical work than leaders in other branches [60], thus having less time to familiarize themselves with digital innovations, impacting their readiness for adoption.

Research findings indicate that a lack of knowledge about VR technologies influences the adoption of these technologies [23,26,61]. Our results regarding the readiness of HC professionals to adopt VR technologies reveal differences between individuals who have gained experience with VR technologies and those who have not. In particular, the characteristics of the innovation, which significantly influence adoption behavior [28], are differently evaluated by the two groups. For instance, individuals without VR experience perceive the costs and the effort for training as high and consider them as obstacles to their utilization. Conversely, individuals with VR experience consider the costs and the training effort affordable and are not deterred by them. As VR is no longer a new technology, the acquisition costs have fallen [62]. This could lead to the assumption that HC professionals without experience cannot estimate the costs, rely on incorrect or outdated knowledge, and abandon the effort associated with introducing new technologies.

Furthermore, non-VR user's express concerns about being replaced by VR technologies or that the doctor-patient relationship may be negatively affected. This phenomenon is termed technophobia [63], encompassing any hesitation, reservation, skepticism, concern, fear, or dread regarding implementing technology in clinical practice [64]. These concerns are irrelevant among individuals who have gained experience with VR technologies. Studies indicate that the frequency of usage increases comfort with the technology and willingness to use it [65]. Ultimately, a lack of knowledge exacerbates concerns and thus can hinder potential utilization.

Both innovators and laggards express the need for evidence-based studies to reduce uncertainties regarding the efficacy and safety of VR technologies. This is an interesting finding, as according to Rogers [28], information acquisition in the adoption decision process often lacks systematic reliance on scientific insights. This less science-oriented approach is also evident in medical practice, where HC professionals increasingly incorporate individual assessments into the selection and implementation of digital innovations rather than accessing evidence-based insights [59]. This could be attributed to challenges in researching and evaluating information on digital innovations. The question arises of how, considering the time constraints of HC professionals, the efficacy and safety of VR technologies can be effectively communicated to provide them with easy access to evidence-based information sources.

In this study, knowledge transfer and communication between the two adopter groups appears to be difficult. This is particularly true as respondents from the VR experienced HC professionals see themselves as opinion leaders but not as responsible for passing on knowledge. The results show a

lack of precisely this adoption group, which contributes to the dissemination of knowledge. A group between the innovators and laggards, such as the "early majority" or "late majority," who are typically well-connected with their colleagues, could contribute to this lack of communication and knowledge transfer, and thus, according to Rogers [28], lead to a leap between the adopter groups and consequently contribute to the dissemination of technologies like VR. Overall, adopter group-specific and balanced information dissemination about VR technologies is necessary to promote adequate utilization in HC and address potential concerns.

***Data security*.**
Data security is already well recognized and researched in the literature on technology adoption in HC [66]. The metaverse trend brings new and heightened concern around data security issues [2]. This is because the private and sensitive information leaked via the metaverse can include real-world data about user behavior and physiological characteristics [67].

The interview findings reveal a discrepancy in the perceived importance of data security between participants with and without VR experience. Those with VR experience tend to assign less significance to data security concerns than their counterparts lacking VR experience, who express heightened apprehension. In most cases, the reason given was "*medical data is stored [through the use of VR technologies]"* (e.g., MTF1; np). However, using VR technologies does not always involve collecting and storing sensitive patient data. This was also argued by participant PT3 (p), who said: "[...] I always switch on the [VR] device, and it does not store any data. I do not have to enter a name, [...] just press the button and go." It can, therefore, be concluded that medical staff without VR experience lack knowledge about VR and data protection and subconsciously use this argument to avoid using VR.

Studies have shown that HC professionals lack awareness of data security [68]. Lack of staff awareness meant that the safety risk assessment was not considered in any form. In pervasive practice, there is no level of concern or caution regarding data security in HC [69]. Our interviewees disagreed on whether data security is important when using VR. Non-VR users demonstrated heightened awareness and concern regarding data security, whereas those using VR appeared less inclined to perceive security challenges.

Theoretical Contribution and Practical Implications

Our contribution to theory is two-fold. First, this study advances the DOI literature and follows Burton-Jones and Volkoff's [70] call for context-specific rather than general perspectives. We find evidence for the applicability of Rogers' [28] adoption decision process to the context of medical rehabilitation by identifying 26 factors that influence the adoption or rejection of HC professionals regarding VR technologies in medical rehabilitation. Our study, therefore, provides valuable findings that can be used to promote VR technology diffusion in the HC sector. Second, our study contributes to theory by going beyond a hypothetical usage scenario by categorizing HC professionals into two user groups: with professional and those without experience with VR technologies. In line with previous research [25,61], we hypothesize that the inclusion of actual usage experiences beyond solely the intention to use will enhance the explanatory power of the findings. The two user groups do not agree on some points or even have opposing opinions. This can be attributed to different levels of knowledge and individual characteristics, which can hinder the diffusion of VR technologies and should, therefore, be addressed with individual, adopter-specific communication strategies.
In addition to the theoretical contributions, we derived two practical implications. First, our results suggest that HC professionals desire enhanced education through various channels, including from

leaders, as well as during medical education, and through events and social media. A stronger focus on VR technologies in medical rehabilitation in politics, health insurers, and HC organizations can contribute to the dissemination of knowledge. Through these stakeholders, education and knowledge can be offered to reduce fear and questions about VR technologies. This can be supported by disseminating evidence-based information via rehabilitation-specific journals and the involvement of the advocacy group of the therapy professions to overcome the knowledge gap among HC professionals with and without experience. By anchoring VR technologies in the S-3 guidelines, the decision-making process of HC professionals regarding a suitable VR technology can be supported. Second, given the heightened data security concerns among non-VR users, providing clear, accurate information on data protection measures associated with VR technologies is essential. There is a clear need for future educational initiatives aimed at informing HC professionals about the specific technologies that require strict attention to data security. Developing guidelines and protocols that assure data security can help alleviate fears and misconceptions about VR usage.

Limitations

This paper has several limitations that suggest potential areas for future research. The first limitation results from the qualitative research approach as we cannot conclude entire populations, affecting our results' generalizability. To mitigate the limitation of a small sample size, we selected a diverse sample in terms of age, gender, and profession. By leveraging the strengths of the qualitative approach, we were able to capture rich and diverse data in a new area of research that quantitative studies may not capture. Thereby, we follow the call for research of Halbig et al. [17], who recommend interviews to obtain more in-depth information on VR technology (non)adoption by HC professionals. Second, regarding the DOI theory, our results also provide a basis for further research. So far, the respondents have assessed the effect of the identified factors (resistant or acceptant) very differently. A quantitative study with a large number of participants could investigate which factors are more likely to lead to adoption or resistance. In addition, a survey of individual personality traits using established scales such as the "Big Five" could allow a clearer distinction to be made between the five adopter groups of Rogers [28]. The third constraint of our study stems from the data analysis approach of the QCA, which comes along with the potential bias of the researcher. Personal bias can occur while coding, categorizing, and interpreting textual content. We mitigate this bias by engaging in regular research sessions with the author team to discuss memos and codes.

Conclusion and Further Research

In conclusion, this study elucidates the factors influencing HC professionals' (non)adoption of VR technologies in medical rehabilitation based on their previous experiences. Despite the demonstrated benefits of VR in enhancing patient care and rehabilitation outcomes, its clinical adoption remains limited mainly due to concerns about cost and data security, which can be attributed to the insufficient knowledge of the potential users. By analyzing 23 semi-structured interviews with HC professionals in Germany, we identified 26 factors within four categories that explain the (non)adoption of VR technologies. Distinguishing between VR-experienced "innovators" and non-experienced "laggards," our findings highlight the importance of addressing these groups' unique needs to promote wider adoption. This research contributes to the DOI literature by providing a nuanced understanding of technology adoption in the HC, incorporating the specific needs and concerns of two different adopter groups. It thus identifies the critical barriers and enables targeted strategies to promote VR integration. Future research can focus on developing and validating strategies to improve the uptake of VR technologies, using the identified factors as a basic framework. Ultimately, our insights offer practical guidance for enhancing the development and implementation of metaverse technologies in the future of medical rehabilitation.

Conflicts of Interest

None declared.

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Abbreviations

DOI: Diffusion of innovation
HC: Healthcare
QCA: Qualitative content analysis
TAM: Technology acceptance model
UTAUT: Unified theory of acceptance and use of technology
VR: Virtual reality

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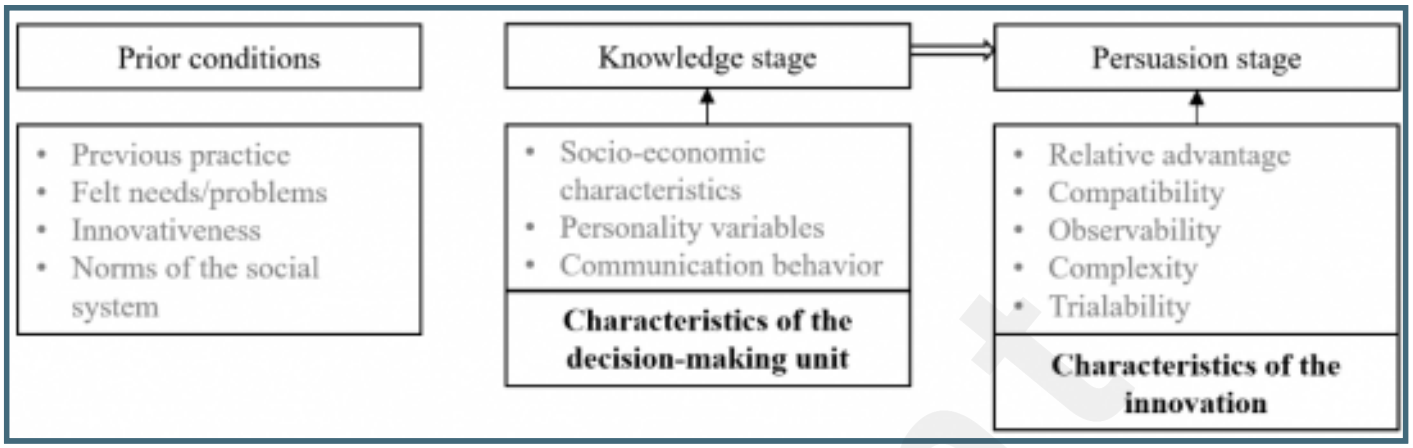
Prior conditions, knowledge stage and persuasion stage within the adoption decision process.



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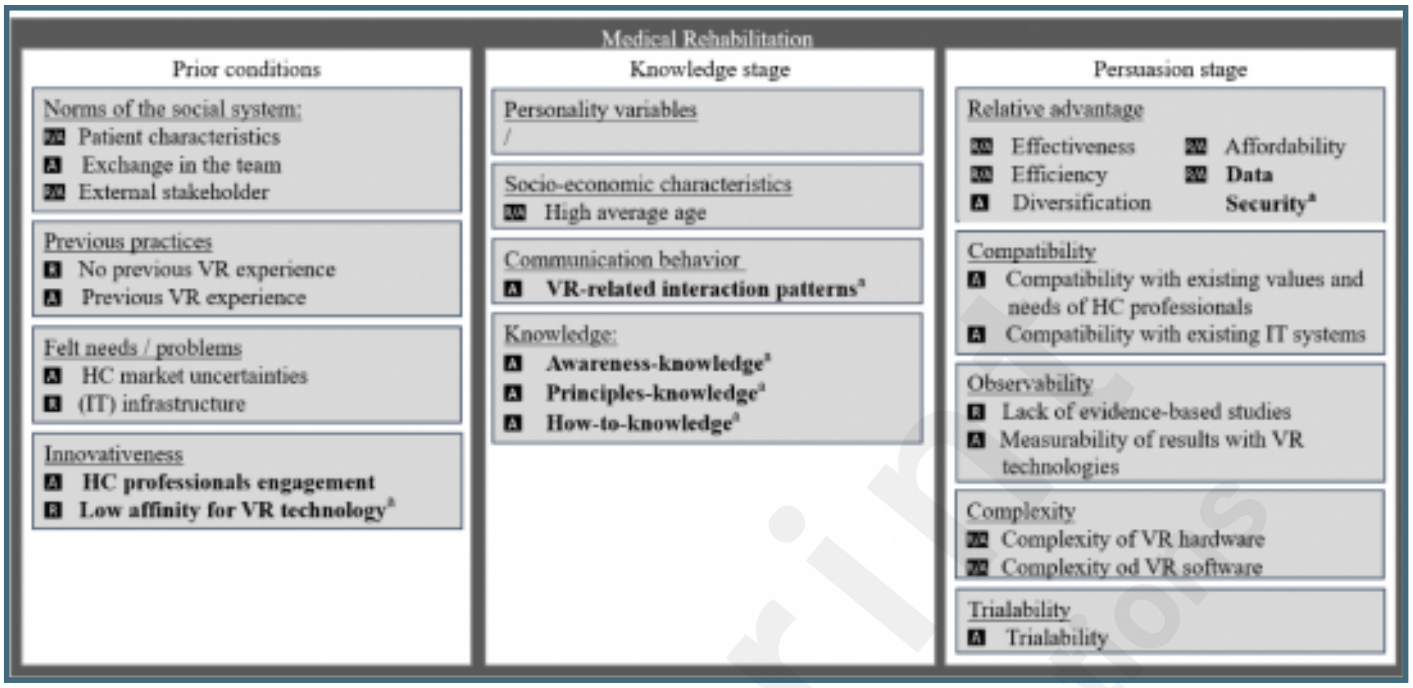
Contributing factors to resistance and adoption of VR technologies in medical rehabilitation.



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