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THE GAMIFICATION OF REHABILITATION: A NARRATIVE REVIEW OF SOCIAL AND BEHAVIORAL IMPACTS

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ABSTRACT

Objectives: This narrative review aims to critically examine gamified rehabilitation as a socio-technical phenomenon. It evaluates clinical effectiveness, analyzes underlying behavioral and motivational mechanisms, explores social implications-including equity, digital inclusion, and social connectivity-and assesses the regulatory and governance challenges associated with implementing digital health technologies in clinical and home-based settings.
Methods: Adopting a concept-driven framework and a socio-technical perspective, this study synthesized peer-reviewed research identified through PubMed, Scopus, and Web of Science. The review focuses on virtual reality (VR) and "exergames" applied to orthopaedic, neurological, and chronic conditions. Information was extracted regarding clinical metrics, psychological indicators grounded in Self-Determination Theory (SDT), and systemic impacts on healthcare delivery.
Findings: The review indicates that gamified interventions are clinically effective, particularly for improving balance in neurorehabilitation, while significantly enhancing patient engagement and adherence. Success is driven by satisfying core psychological needs for autonomy, competence, and relatedness, often facilitated by AI-driven adaptive difficulty to induce "flow" states. However, the "digital divide" remains a critical barrier, potentially exacerbating health inequalities. Identified risks include behavioral dysregulation, system dependency, and ethical concerns regarding "black-box" algorithms and data privacy. Economically, these systems support health system sustainability through decentralized, asynchronous care models that reduce personnel costs.
Conclusions: Gamification represents a transformative shift toward decentralized, home-based rehabilitation. While enhancing adherence through neurobiological reinforcement, its long-term success requires a socio-technical approach that aligns technical architecture with users' cultural and environmental contexts. Future integration must prioritize inclusive design, modernized reimbursement structures, and robust regulatory compliance to ensure equitable access.

KEYWORDS

Gamification, Rehabilitation, Virtual Reality, Tele-Rehabilitation, Exergames, Digital Health

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1. Introduction

1.1. The Digital Transformation of Rehabilitation in the Digital Era

Transition from Clinical to Home-Based Models The landscape of healthcare is undergoing a significant transition toward decentralized models, moving the primary point of care from inpatient clinics directly to the home environment. This shift is fundamentally driven by the need for health system sustainability and increased resource efficiency. Evidence demonstrates that high-dose neurorehabilitation can be delivered efficiently using consumer-grade technology, achieving therapeutic goals with significantly fewer in-person professional interventions (Arbuckle et al., 2025). Such models rely on asynchronous training, which drastically reduces personnel expenditure by requiring direct therapist presence for only a small fraction of the total training dose (Arbuckle et al., 2025). Furthermore, home-based rehabilitation offers substantial indirect cost savings for patients by reducing travel time and related expenses (Baek et al., 2025).

The Rise of Tele-rehabilitation and VR The integration of Virtual Reality (VR) and "exergames" has shown immense clinical promise in augmenting physical therapy. VR interventions have proven particularly effective in neurorehabilitation, such as significantly improving balance function in patients with Parkinson's disease (Kwon et al., 2023). These technologies facilitate a sense of "telepresence" through real-time data visualization and verbal communication, bridging the physical gap between the clinic and the home (Liu et al., 2022). Moreover, the use of wearable biosensors-capturing metrics such as ECG, EEG, and gait patterns-

allows for the continuous monitoring of sensitive biometric data, ensuring that remote interventions remain data-driven and clinically monitored (Zendehbad et al., 2025).

Aging Population and Growing Demand The digitization of services is increasingly vital to meet the growing demand for rehabilitation among aging populations. For older adults, physical inactivity and a lack of motivation represent primary barriers to health (Shah et al., 2022). Research indicates that rhythm-based VR interventions, such as "Beat Saber," are well-tolerated by the "oldest-old" and lead to significant improvements in handgrip strength and functional performance (Grzywacz et al., 2026). However, the expansion of these tools must account for the "digital divide," which is now recognized as a super determinant of health (Bradway et al., 2026). Older adults often face a second-level digital divide, characterized by limited digital skills and a lack of familiarity with technology, which can result in cognitive overload or resistance to change (Bradway et al., 2026; Koehle et al., 2022; Nasri et al., 2025).

1.2. Gamification as a New Therapeutic Paradigm

Definition of Gamification vs. Serious Games vs. Exergames The gamification of rehabilitation is defined as the application of game-design principles within clinical contexts to enhance patient motivation and self-management (Nasri et al., 2025). Within this paradigm, the literature distinguishes between various digital interventions based on their primary mechanics and immersive qualities. Exergames are characterized as immersive, VR-based exercise video games that situate users within three-dimensional landscapes tailored to their preferences (Shah et al., 2023). These tools effectively transform repetitive physical exercises into enjoyable activities (Shah et al., 2022). In contrast, serious games often embed rehabilitation tasks within a story-driven context or "quest," providing a situational "why" for repetitive therapeutic movements (Nasri et al., 2025; Ion et al., 2026). Such immersive serious games have demonstrated high compliance and physical performance even beyond the initial novelty period of the technology (Elor et al., 2022).

Integration of Game Elements in Medicine The integration of gamification represents a fundamental shift from traditional, often monotonous rehabilitation protocols toward interactive systems designed to foster long-term behavioral change (Nasri et al., 2025; Emaliyawati et al., 2025). These interventions are increasingly grounded in Self-Determination Theory (SDT), which emphasizes the fulfillment of three core psychological needs: autonomy, competence, and relatedness (Patrick & Williams, 2012; Ede, 2022; Simpson, 2021). Autonomy is supported through features that enable personalized goal-setting and user-defined targets, effectively shifting the perceived locus of control from the healthcare provider to the individual (Nasri et al., 2025; Patrick & Williams, 2012). Competence is reinforced through skill-based progression and immediate feedback loops-such as mastery indicators and progress charts-allowing patients to clearly perceive their capacity for achieving specific health outcomes (Nasri et al., 2025; Patrick & Williams, 2012). Finally, relatedness is addressed via social gaming elements, including leaderboards and collaborative challenges, which foster a sense of community among patients facing similar clinical journeys (Nasri et al., 2025; Patrick & Williams, 2012).

Beyond psychological frameworks, these systems incorporate specific mechanics such as challenges, scores, virtual trainers, and sensory feedback to increase patient enjoyment and willingness to participate (Kwon et al., 2023; Elor et al., 2022). Furthermore, advanced integrations utilize Artificial Intelligence (AI) and machine learning to drive adaptive difficulty, ensuring patients remain within their "zone of proximal development" to facilitate a state of "flow"-a condition of deep absorption and optimal performance (Attoh-Mensah et al., 2025; Nasri et al., 2025).

1.3. Research Gap

Despite the rapid expansion of gamified rehabilitation systems, the current body of literature remains predominantly centered on clinical effectiveness, with a strong emphasis on measurable functional outcomes. Most studies evaluate improvements in physical performance, balance, or pain reduction, while comparatively less attention is given to broader dimensions of patient experience and long-term well-being. For example, evidence indicates that while gamified and VR-based interventions can improve specific clinical parameters, such as balance in neurological conditions or localized functional performance, these improvements do not consistently translate into broader gains in daily functioning or quality of life (Evans et al., 2023; Kwon et al., 2023). Furthermore, studies highlight a divergence between clinical recovery and psychosocial outcomes, emphasizing that functional gains may occur independently of improvements in emotional well-being or social integration (Garofano et al., 2025; Fadzillah et al., 2025). This discrepancy underscores the limitations of outcome frameworks that prioritize biomedical indicators without integrating behavioral and social dimensions.

A significant gap also exists in the analysis of inequalities associated with the adoption of gamified rehabilitation. The reviewed literature identifies the digital divide as a critical determinant shaping access to these technologies, with disparities emerging across age, socioeconomic status, and geographic regions (Bradway et al., 2026; Koehle et al., 2022). While digital rehabilitation platforms have the potential to democratize access to care through home-based and asynchronous models (Arbuckle et al., 2025), they simultaneously risk exacerbating existing health inequities when access to infrastructure, digital literacy, or financial resources is uneven (Dereje et al., 2025; Mitchell et al., 2023). In particular, older adults and populations in low-resource settings face barriers related to technological competence, affordability, and cultural adaptation, which remain insufficiently addressed in current research (Nasri et al., 2025; Bradway et al., 2026).

Moreover, the long-term behavioral consequences of gamified systems remain underexplored. Although gamification is consistently associated with increased engagement, motivation, and adherence (Evans et al., 2023; Elor et al., 2022), the literature raises concerns regarding potential behavioral dysregulation and system dependency. Mechanisms such as variable reward schedules, external incentives, and retention-oriented design may, in some cases, shift motivation toward extrinsic drivers or foster compulsive usage patterns (Mohd Tuah et al., 2021; Kuo et al., 2024). Additionally, the tension between fostering autonomous motivation and risking dependency on digital environments is emphasized within theoretical frameworks grounded in SDT (Ede, 2022; Simpson, 2021; Nasri et al., 2025).

Another underdeveloped area concerns regulatory and governance implications. Gamified rehabilitation systems increasingly function as software-based medical devices, requiring compliance with regulatory frameworks such as the FDA classification of medical software and the European Union's Medical Device Regulation (Salisbury, 2021; Martjan et al., 2025). At the same time, the integration of AI and continuous biometric monitoring introduces challenges related to transparency, accountability, and informed consent (Gerke et al., 2020; Zendehbad et al., 2025). Issues such as algorithmic opacity ("black-box" AI), data privacy risks, and lack of interoperability between proprietary systems and healthcare infrastructures further complicate their safe and ethical implementation (Carter et al., 2020; Korkmaz, 2026).

Finally, the broader impact of gamified rehabilitation on healthcare systems remains insufficiently examined. Although evidence suggests that decentralized, home-based models can improve cost-efficiency, reduce clinician workload, and support system sustainability (Arbuckle et al., 2025; Jeilani & Hussein, 2025), there is a lack of comprehensive, long-term evaluations of how these innovations reshape healthcare delivery and policy. In particular, challenges related to reimbursement models, scalability, and integration with existing healthcare infrastructures remain unresolved (Reilly & Molnar, 2025; Sareban et al., 2025).

1.4. Aim of the Study

In response to these gaps, this narrative review aims to critically examine gamified rehabilitation as a socio-technical phenomenon situated at the intersection of digital health, behavioral science, and healthcare systems. Specifically, the review seeks to evaluate the clinical effectiveness of gamified interventions, analyze the underlying behavioral and motivational mechanisms, explore their social implications-including issues of equity, digital inclusion, social connectivity and assess the regulatory and governance challenges associated with their implementation. By adopting an integrated perspective, this study aims to provide a comprehensive understanding of how gamified rehabilitation influences not only therapeutic outcomes but also patient behavior, social participation, and the evolving structure of digital healthcare ecosystems.

2. Methodology

The methodology of this narrative review is designed to provide a selective and interpretative synthesis of the social and behavioral implications of gamified rehabilitation. In alignment with the interdisciplinary focus of the *International Journal of Innovative Technologies in Social Science*, the approach emphasizes a socio-technical perspective, examining the convergence of digital innovation, behavioral science, and social systems. Rather than adhering to an exhaustive systematic protocol, the review adopts a concept-driven framework to identify and discuss the transformative potential and systemic challenges associated with gamified therapeutic interventions.

2.1 Literature Identification and Scope

Literature was identified through targeted searches of prominent biomedical and technological databases, such as PubMed, Scopus, and Web of Science. The identification process aimed to capture a representative and high-impact corpus of peer-reviewed research across multiple domains, focusing specifically on the integration of gamification, VR, and immersive technologies within clinical and home-based settings. The scope of the review encompasses behavioral research addressing orthopaedic, neurological, and chronic conditions, alongside technological advancements in robotic exoskeletons, haptic feedback devices, and brain-computer interface (BCI) systems. Furthermore, the selection strategy prioritized research grounded in established psychological frameworks, notably SDT and neurobiological models of reinforcement learning, to ensure a robust theoretical foundation for the subsequent discussion.

2.2 Selection and Conceptual Alignment

The selection of sources was guided by their relevance to the thematic scope of the review, prioritizing studies that provide meaningful insights into the human-technology interaction. We focused on research reporting clinical and behavioral outcomes, such as patient engagement, adherence, and self-regulatory efficacy, as well as those addressing broader social dimensions like digital connectivity and the mitigation of isolation through "telepresence." The review maintains a comprehensive lifespan perspective, incorporating evidence from pediatric populations through to the "oldest-old." Conversely, the selection excluded highly technical reports focusing exclusively on software architecture without assessing behavioral or social impacts. Similarly, general gaming literature not applied to clinical rehabilitation or health-promoting behaviors was omitted to maintain the review’s focus on the digital healthcare ecosystem.

2.3 Analytical Framework and Thematic Synthesis

The synthesis was guided by an interpretative analytical approach, designed to bridge the gap between technical innovation and practical social implementation. Information was extracted discursively, focusing on clinical metrics such as functional recovery and pain reduction alongside psychological indicators like "flow" states and intrinsic motivation scores. The analysis also captured the role of granular biometric data-including EEG, eye-tracking, and electrodermal activity-in facilitating personalized rehabilitation.

This evidence was organized into distinct thematic clusters reflecting the multifaceted impact of gamification. The synthesis first evaluates the clinical effectiveness of these systems before moving into a deeper exploration of the psychological architecture of engagement, particularly the transition from extrinsic rewards to autonomous regulation. Further thematic layers address the social implications of multiplayer environments, the risks of behavioral dysregulation and system dependency, and the economic sustainability of decentralized, home-based care. By adopting this socio-technical perspective, the review ensures that the findings are interpreted through the lens of the patient as a socially embedded individual, acknowledging that the success of digital rehabilitation is determined by the interaction between technical design and the user's environmental context.

3. Results

3.1 Clinical and Behavioral Effectiveness of Gamified Rehabilitation

The clinical and behavioral effectiveness of gamified rehabilitation and VR has been evaluated across various orthopaedic, neurological, and chronic conditions (Evans et al., 2023; Kwon et al., 2023). While evidence suggests gamified interventions are similarly effective, though not strictly superior, to conventional physical therapy in orthopaedic applications (Evans et al., 2023), VR interventions have shown specific targeted benefits in neurorehabilitation. For instance, a meta-analysis found that VR significantly improves balance function in Parkinson's disease compared to standard treatments, despite showing no statistically significant differences in overall gait ability, activities of daily living, or motor function (Kwon et al., 2023). Furthermore, researchers have explored the feasibility of immersive VR-enhanced exoskeletons for post-stroke and elderly assistance (Elor et al., 2022), and noted that home-based VR allows for convenient utilization in patients' own homes (Kwon et al., 2023). Beyond physical metrics, gamification possesses the distinct potential to improve patient engagement, satisfaction, and adherence to recovery programs by introducing methods that increase motivation (Evans et al., 2023). Incorporating interactive features and gamification elements-such as challenge and score, self-competition, virtual trainers, and sensory feedback-increases patient enjoyment and willingness to participate, potentially leading to better training outcomes (Kwon et al., 2023; Elor et al., 2022). Sustained participation can be further facilitated by applying concepts from SDT to intrinsically motivate users:

building relatedness through narrative helping behaviors, fostering competence, and enabling autonomy through progressive difficulty alongside immediate feedback (Elor et al., 2022). Addressing the challenge of maintaining engagement beyond the initial novelty period of VR technology, one study demonstrated that an immersive VR serious game for upper-extremity exercise induced high compliance and physical performance, even with increasing difficulty beyond the novelty effect period (Elor et al., 2022). Users perceived that they gained significant strength and stability through playing the game (Elor et al., 2022), suggesting that the creation of adaptive, personalized games that adjust to a user's mental and physical state in runtime may yield immense potential (Elor et al., 2022). Ultimately, even if gamification achieves the same functional results as conventional physical therapy methods, it provides a viable alternative that can improve patient engagement and satisfaction (Evans et al., 2023).

3.2 Psychology of Play and Motivational Mechanisms in Chronic Illness

The integration of gamification into digital healthcare represents a shift from traditional, often monotonous rehabilitation protocols to interactive systems designed to foster long-term behavioral change (Nasri et al., 2025; Emaliyawati et al., 2025). Evidence across multiple studies indicates that these interventions are increasingly grounded in established psychological and neurobiological frameworks, specifically targeting the transition from external compliance to internal drive (Patrick & Williams, 2012; Ede, 2022). The literature suggests that the effectiveness of gamified rehabilitation is largely predicated on its ability to satisfy core psychological needs while simultaneously leveraging natural reinforcement learning mechanisms (Glimcher, 2011; Simpson, 2021). Within this context, the application of SDT emerges as a primary theoretical foundation, emphasizing the three pillars of autonomy, competence, and relatedness as essential for optimal patient functioning and sustained motivation (Patrick & Williams, 2012; Ede, 2022; Simpson, 2021).

Across various reviewed interventions, the support of patient autonomy is achieved through features that allow for personalized goal-setting and user-defined targets, thereby shifting the perceived locus of control from the healthcare provider to the individual (Nasri et al., 2025; Patrick & Williams, 2012). Research distinguishes between autonomous motivation-where patients act out of personal value or inherent interest-and controlled motivation, which is driven by external rewards or internal pressures such as guilt (Ede, 2022; Simpson, 2021). Findings indicate that interventions promoting autonomous regulation result in significantly better maintenance of health behaviors, such as medication adherence and physical activity levels, compared to those relying on purely extrinsic pressures (Emaliyawati et al., 2025; Simpson, 2021). Competence is further reinforced through skill-based progression and immediate feedback loops, such as mastery indicators and progress charts, which allow patients to perceive their own capacity for achieving desired health outcomes (Nasri et al., 2025; Patrick & Williams, 2012). For instance, studies on patients with osteoarthritis and those undergoing BCI rehabilitation report that providing skill-appropriate challenges and clear performance metrics significantly improved self-perceived functional capacity and overall task enjoyment (Nasri et al., 2025; de Castro-Cros et al., 2020).

Relatedness is addressed through social gaming elements, including leaderboards and collaborative challenges, which foster a sense of community and shared experience among patients facing similar health challenges (Nasri et al., 2025; Patrick & Williams, 2012). The role of the practitioner is also highlighted as a critical component of this social dynamic; evidence shows that when healthcare providers create an autonomy-supportive environment, patients exhibit higher levels of perceived competence and autonomous motivation (Patrick & Williams, 2012; Simpson, 2021). This psychological fulfillment is reflected in results from the Intrinsic Motivation Inventory (IMI), where gamified rehabilitation tasks consistently yield higher scores for interest and enjoyment compared to standard, non-gamified protocols (de Castro-Cros et al., 2020)

The psychological impact of gamification is complemented by neurobiological processes centered on dopamine-driven reinforcement learning (Glimcher, 2011). Research identifies the dopamine "reward prediction error" (RPE) as a fundamental mechanism for behavioral change, where phasic activity in midbrain dopaminergic neurons encodes the discrepancy between expected and actual rewards (Glimcher, 2011). Gamified systems exploit this by providing unexpected rewards-such as bonus points or virtual "power-ups"-which trigger synaptic modifications in the basal ganglia and frontal cortex (Glimcher, 2011). This neurobiological reinforcement is particularly critical in clinical applications such as stroke recovery, where high intensity and a high number of repetitions are required to overcome the "learned non-use" phenomenon (Ion et al., 2026). While these rewards leverage behavioral economic principles like present bias-providing immediate gratification for behaviors with long-term health benefits-the literature also notes the use of loss aversion, where patients are motivated to hit daily targets to avoid losing previously earned status or virtual currency (Nasri et al., 2025).

The relationship between gamification and intrinsic motivation remains a complex area of synthesis across the reviewed literature (Nasri et al., 2025; Ede, 2022). While extrinsic rewards like badges and points provide an initial "hook" for engagement, studies caution that these elements may paradoxically undermine patient autonomy if perceived as external pressures (Nasri et al., 2025). This phenomenon is described in specific educational and psychological research as a "crowding out" effect, where the introduction of extrinsic rewards can decrease the intrinsic motivation of a learner (Ede, 2022). However, longitudinal data suggest that "meaningful gamification"-where game design elements are deeply integrated into the clinical task rather than being superficial additions-can actually enhance intrinsic interest (Ede, 2022). In BCI functional rehabilitation, for example, patients in gamified groups reported lower levels of pressure and tension ($p=0.04$) alongside higher perceived competence ($p=0.03$), indicating that well-designed game mechanics can support rather than replace the patient's internal motivation (de Castro-Cros et al., 2020).

System personalization and the use of AI to drive adaptive difficulty are identified as key factors in maintaining engagement (Nasri et al., 2025; Attoh-Mensah et al., 2025). Several studies report that "one-size-fits-all" approaches are often ineffective because they fail to account for the varying physical and cognitive states of individuals with chronic illness (Nasri et al., 2025; Attoh-Mensah et al., 2025). AI-driven systems process real-time biometric and performance data to adjust task complexity, ensuring the patient remains within their "zone of proximal development" (Attoh-Mensah et al., 2025; Emaliyawati et al., 2025). This dynamic adjustment is essential for facilitating a state of "flow"-a psychological condition of deep absorption and optimal performance where the challenge of the task is perfectly balanced with the user's skill level (Nasri et al., 2025; Tong et al., 2025). Machine learning algorithms further allow for "temporal adaptation," aligning rehabilitation tasks with a patient’s individual energy profiles and daily routines to maximize adherence (Nasri et al., 2025).

Immersive technologies, particularly VR, further enhance these motivational mechanisms through the concepts of presence and narrative transportation (Ion et al., 2026; Wang & Cheng, 2022). Evidence indicates that embedding rehabilitation tasks within a story-driven context or "quest" provides a situational context and a "why" for repetitive therapeutic movements (Nasri et al., 2025; Ion et al., 2026). This narrative immersion is reported to reduce the perceived effort and physical discomfort associated with therapy, as patients focus on the virtual objectives rather than the physical strain (Ion et al., 2026). Studies in stroke rehabilitation show that VR-based interventions often result in higher adherence and longer training durations compared to traditional exercises, as the multisensory feedback and immersive environments provide a more compelling experience (Ion et al., 2026).

The impact of gamification is notably influenced by age, with distinct motivational profiles observed across the lifespan (Nasri et al., 2025; Subramanian et al., 2020). In pediatric populations, gamified interventions featuring virtual avatars and mini-games have demonstrated success in improving clinical markers, such as glycaemic control in children with Type 1 diabetes (Nasri et al., 2025; Emaliyawati et al., 2025). In contrast, research indicates a divergence in motivations between age groups: younger adults are primarily motivated by competition and high-score systems, whereas older adults prioritize the perceived physical and cognitive health effects and the general joy of playing (Subramanian et al., 2020). Cross-sectional studies report that younger adults achieve significantly higher flow experiences in dimensions such as "challenge-skill balance" ($p=0.01$) (Tong et al., 2025). Older adults, however, may face a "digital divide," reporting higher instances of cognitive overload and frustration with complex interfaces, suggesting they respond better to clear feedback and social connection rather than high-intensity competition (Nasri et al., 2025; Tong et al., 2025).

Finally, the literature addresses the tension between supporting patient autonomy and creating system dependency (Nasri et al., 2025; Wang & Cheng, 2022; Simpson, 2021). While frameworks centered on the internalization of health behaviors promote self-regulation that persists even after the intervention ends, there are concerns regarding the potential for dependency (Patrick & Williams, 2012; Ede, 2022; Simpson, 2021). Some studies suggest that an over-reliance on external rewards or "black-box" AI adjustments may make health behaviors contingent upon the presence of the game environment (Nasri et al., 2025; Wang & Cheng, 2022). Furthermore, while social and achievement motivations are generally linked to positive engagement, the motive of "escapism" within virtual worlds is reported to have the strongest positive correlation with problematic usage and Internet Gaming Disorder ($r = 0.40$) (Wang & Cheng, 2022). The consensus suggests that gamification successfully supports autonomy when it empowers patients with self-regulatory tools, but it risks fostering dependency when it prioritizes extrinsic manipulation over the clinical internalization of goals (Nasri et al., 2025; Attoh-Mensah et al., 2025; Simpson, 2021).

3.3 Social Connectivity and Reduction of Isolation

Evidence from multiple studies indicates that immersive VR and gamified platforms provide high-quality digital environments that serve as effective practicing grounds for social interaction and rehabilitation (Wang et al., 2025; Lai et al., 2023). Immersive VR-based exercise video games, or exergames, allow users to be situated within three-dimensional landscapes that can be tailored to their preferences, such as nature-based milieus featuring elements like grass, trees, and ambient sounds (Shah et al., 2023). These nature-based virtual environments have been reported to receive positive reception from senior citizens, enhancing their engagement and overall mood (Shah et al., 2022). Furthermore, modular platforms such as "Max Well-Being" have been developed to allow diverse forms of input to be mapped to in-game button commands, providing the flexibility for medical specialists to adjust digital environments to fit the specific medical conditions and goals of individual patients (Kennard et al., 2024). Standalone VR headsets further enhance these environments by placing users within a customizable "home" digital space that provides a sense of presence and privacy for socializing with peers and coaches (Lai et al., 2023). Technology-based gamification using these digital platforms and graphic interfaces has been shown to amplify interventional outcomes by providing a virtual space for practicing social cognition training and social exchanges (Wang et al., 2025).

Across the reviewed interventions, the integration of social dimensions into exergaming has been identified as a critical factor in building online communities and reducing social isolation (Shah et al., 2022; Lai et al., 2023). Research highlights that over 70% of gamers play with others, either in person or online, with social interaction often cited as the most important influence on player interest and involvement in long-term interventions (Marker & Staiano, 2015). Social VR enables distributed connections over wireless networks, allowing users to communicate through embodied avatars and voice communication from any location (Shah et al., 2022). In studies involving adolescents with physical disabilities, participants used multiplayer games such as VRChat and RecRoom to meet peers in private digital parties, which facilitated friendship building and meaningful social interaction (Lai et al., 2023). Most participants in these studies reported becoming friends with their peers in the program, with some establishing strong bonds that extended to out-of-class play sessions (Lai et al., 2023). The use of digital avatars as representations of the self allowed users to interact in a variety of digital settings, which was found to be particularly valuable for individuals who felt "out of place" in traditional social environments due to their disabilities (Lai et al., 2023).

Further supporting this digital integration, evidence suggests that home-based telerehabilitation systems significantly enhance therapist-patient remote interaction (Liu et al., 2022). These systems often include robotic exoskeletons and haptic feedback devices, allowing therapists to remotely monitor movements and dynamically adjust the intensity of rehabilitation therapy (Liu et al., 2022). Real-time data visualization and verbal communication through telecommunication networks provide a form of "telepresence" that bridges the gap between the clinic and the home (Liu et al., 2022). For individuals with Parkinson’s disease, gamification-based telerehabilitation has been shown to maintain high levels of motivation and adherence in home settings, effectively managing motor symptoms like balance and gait (Norouzi-Ghazbi et al., 2025). Similarly, gamified digital health interventions for stroke survivors have demonstrated safety and feasibility, with several randomized controlled trials reporting significant improvements in attentional performance (Nugraha et al., 2025). Such systems allow patients to receive specialist treatment without the need for time-consuming travel, thereby alleviating the burden on the healthcare system (Liu et al., 2022).

Several studies reported that these gamified interventions are particularly effective in motivating older adults to participate in physical exercise and improve social connectedness (Shah et al., 2022). For this population, physical inactivity and lack of motivation are common barriers to health; however, exergames can transform repetitive exercises into enjoyable activities (Shah et al., 2022). In group-based exergaming, older participants reported significantly higher levels of enjoyment and effort when playing collaboratively than when playing individually (Shah et al., 2023). Recent research focusing on the "oldest-old" (individuals aged 80 years and older) indicates that rhythm-based VR interventions, such as the game "Beat Saber," are well-tolerated and result in significant improvements in handgrip strength and lower-limb functional performance (Grzywacz et al., 2026). Additionally, commercial game consoles that utilize full-body movements have been shown to induce "flow-like" states in older adults, providing a meaningful way to socialize with peers while improving mobility and balance (Zlotnik et al., 2023; Shah et al., 2022).

Parallel findings have shown that gamified interventions improve social interaction and communication outcomes for people with various disabilities (Wang et al., 2025; Lai et al., 2023; Nugraha et al., 2025). For children and adolescents with autism spectrum disorder (ASD), gamification elements such as feedback, rewards, and virtual avatars are frequently used to enhance social responsiveness and communication skills

(Wang et al., 2025). Systematic reviews indicate that technology-based gamification, including humanoid robots and VR, can provide a suitable approach for ASD treatment in naturalistic settings (Wang et al., 2025). For adolescents with physical disabilities, home-based multiplayer VR programs have been shown to attenuate real-world social isolation and shyness (Lai et al., 2023). High levels of program satisfaction and enjoyment were reported among these participants, who found that the virtual environment allowed them to engage in social and health-enhancing activities from which they might otherwise be excluded (Lai et al., 2023). Furthermore, gamified interventions targeting attention in stroke survivors have been shown to be safe and feasible, although improvements do not always translate into functional gains in all activities of daily living (Nugraha et al., 2025).

The effectiveness of these social interventions often depends on the game mechanics employed, specifically the role of competition versus cooperation (Shah et al., 2022; Marker & Staiano, 2015). While competitive play has been found to increase energy expenditure and aggression in short bouts, it can also lead to adverse effects, including increased stress and reduced intrinsic motivation (Shah et al., 2022; Marker & Staiano, 2015). In a competitive environment, individuals may feel demoralized if their performance is poor compared to others, which can hinder behavioral change (Marker & Staiano, 2015). In contrast, collaborative play based on joint tasks and collective rewards has been found to yield significantly higher intrinsic motivation and physical exertion (Shah et al., 2023). Cooperation encourages participants to make more effort and fosters social bonding with coplayers over time (Shah et al., 2022; Marker & Staiano, 2015). For chronic stroke survivors, some research suggests that elements of competition could potentially disrupt the rehabilitation process, whereas cooperative play engages participants for longer durations (Hadjipanayi et al., 2025).

The impact of social connectivity is further modulated by the balance between social pressure and social support (Shah et al., 2022; Lai et al., 2023; Hadjipanayi et al., 2025; Marker & Staiano, 2015). Social support and communication inherent in exergame play are proposed as key mediators for adherence to sustained play (Marker & Staiano, 2015). In VR groups, the perceived bond between peers was found to be a determinant of attendance, with participants who established relationships showing higher adherence (Lai et al., 2023). Furthermore, the illusion of "co-presence"-the perception of a virtual agent as a real human-can enhance task engagement and promote perseverance in stroke rehabilitation, even without explicit competition or cooperation (Hadjipanayi et al., 2025). This social facilitation effect is particularly beneficial for motor tasks requiring stamina (Hadjipanayi et al., 2025). Additionally, the involvement of third-party guardians, such as teachers or parents, provides social support that makes gameplay more accessible for children (Wang et al., 2025). Conversely, negative real-world social experiences, such as bullying, were identified as factors that increased isolation and influenced loneliness scores (Lai et al., 2023).

Despite these benefits, several reports identified barriers to participation related to digital exclusion and technological competence (Liu et al., 2022; Lai et al., 2023; Grzywacz et al., 2026). Older adults are often affected by digital exclusion due to negative beliefs and stereotypes that frame gaming as irrelevant to their age group (Grzywacz et al., 2026). While many participants quickly adapt to handheld controllers, less experienced users often struggle with navigating user interfaces and operating complex controls (Lai et al., 2023). This exclusion can impede performance and attendance, sometimes leading to program withdrawal (Lai et al., 2023). Families unfamiliar with video game technology often require ongoing technical support and instruction to facilitate home-based interventions (Lai et al., 2023). To address these barriers, newer platforms are being designed with streamlined user interfaces that allow both specialists and patients to operate systems without technical training (Kennard et al., 2024). Both patients and therapists face a learning curve in telerehabilitation, and the need for online tutorials and troubleshooting assistance remains a critical factor for program success (Liu et al., 2022).

3.4 Risk of “Health-Gaming” Dependency and Behavioral Dysregulation

The implementation of gamified rehabilitation has introduced concerns regarding compulsive use and behavioral dysregulation, particularly among vulnerable populations. Studies indicate that individuals with developmental disabilities, such as Attention-Deficit/Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD), are at higher risk for excessive video game use and potential addiction. Evidence suggests that when gaming becomes the primary source for satisfying self-determination needs-such as autonomy, competence, and relatedness-it can lead to significant functional impairment (Kuo et al., 2024). Although prevalence rates for formal diagnoses like Internet Gaming Disorder (IGD) remain relatively low (estimated between 0.3% and 1.0% in the general population), the risk of "high involvement" transitioning into "pathological involvement" is a noted clinical concern (Musetti et al., 2025).

The distinction between therapeutic engagement and behavioral addiction is often marked by the degree of control and functional impairment. While healthy "passionate" gamers may spend more than four hours daily playing without psychological maladjustment, disordered gaming is characterized by a persistent pattern of impaired control over gaming onset, frequency, and duration (Kuo et al., 2024; Musetti et al., 2025). Research shows that disordered gamers often spend more than six hours per day on video games and experience the highest levels of impairment in personal, social, and educational functioning. Furthermore, common features of behavioral addiction, such as tolerance (increasing time to achieve the same effect) and withdrawal (unpleasant moods when activity is stopped), have been identified in problematic gaming patterns (Kuo et al., 2024; Musetti et al., 2025).

The use of specific game mechanics, particularly those based on "variable reward schedules" or in-game rewards, is a primary driver for continued and potentially compulsive engagement. Gamification elements such as points, leveling systems, and badges act as external stimuli that incite motivational needs and provide immediate feedback, which can lead to recurring immersive experiences (Mohd Tuah et al., 2021). However, these same mechanics can create a rapid reward-reinforcement response similar to problem gambling, particularly when combined with in-game economics such as "loot boxes" that offer unknown content for a fee.

The commercialization of rehabilitation and the rise of gamified health platforms have introduced business models centered on user retention and engagement. Generic gamification frameworks are frequently designed to optimize task efficiency or improve user retention, often neglecting potential negative consequences or ethical bioethical principles inherent to healthcare. This commercial focus raises the risk of turning health and rehabilitation into "performance metrics" where subjective patient experiences may be placed in an inferior position compared to objective physiological parameters like heart rate or oxygen uptake (Giunti, 2018). Consequently, scholars emphasize that health-oriented gamification requires careful ethical consideration and close monitoring to ensure that the intended therapeutic purpose is not derailed by excessive use or maladaptive behavioral patterns.

In addition to the previously identified risks, researchers note that gamification elements such as points, leaderboards, and leveling systems provide immediate feedback that can lead to recurring immersive experiences. Within the context of occupational therapy, it is observed that while these game-like enhancements increase motivation and engagement, the lack of a uniform terminology in the field can hinder the formal evaluation of their long-term social and behavioral impacts. Furthermore, evidence from the rehabilitation literature suggests that as technology-based interventions become more ubiquitous through personal devices and smartphones, there is an increasing need to monitor how these gamified solutions influence patient autonomy and daily independent living (Zlotnik et al., 2023).

3.5 The Digital Divide in Access to Gamified Rehabilitation

The digitization of healthcare services and information has led to the digital divide being considered a "super determinant of health" (Bradway et al., 2026). Evidence indicates that without specific attention to health equity considerations in design, implementation, and evaluation, the rapid expansion of digital health approaches threatens to exacerbate rather than ameliorate existing health disparities (Koehle et al., 2022). Furthermore, the digital divide results in an exacerbation of existing social inequalities. A primary concern in this landscape is that technology is not universally designed, but instead is primarily made for the "capable or digitally engaged" (Bradway et al., 2026).

These health disparities and digital inequalities face unique contexts in low- and middle-income countries (LMICs). In LMICs, pervasive poverty, limited healthcare infrastructure, and geographical barriers impede equitable access to high-quality rehabilitation care. Financial barriers, where out-of-pocket expenses can exceed 40% of household income, and a critical shortage of rehabilitation professionals further exacerbate the substantial burden of rehabilitation needs in these regions. Despite these challenges, serious games and mobile health applications hold significant potential to offer cost-effective and accessible solutions where conventional rehabilitation services may be unavailable or prohibitively expensive (Dereje et al., 2025).

Implementing digital technologies involves various infrastructural and technological requirements, including physical space, noise levels, and internet connectivity (Mitchell et al., 2023). Additionally, access to internet-capable mobile devices varies widely, reflecting individual and regional socioeconomic power (Koehle et al., 2022). Beyond hardware, the "second-level digital divide" encompasses limited digital skills and lower adoption among older adults (Bradway et al., 2026; Koehle et al., 2022). A primary obstacle is the varying level of digital literacy among older adults, who often report a lack of familiarity with technology, leading to resistance to change and a preference for traditional, in-person interactions (Nasri et al., 2025).

Cultural contexts also influence implementation; localization efforts for serious games must consider language barriers, cultural sensitivities, and the diversity of healthcare practices (Dereje et al., 2025).

One of the main obstacles to gamified rehabilitation is the initial cost of equipment. Implementing VR systems involves significant initial costs, including devices, software, and specialized training for physiotherapists. However, in the long term, this investment can result in savings due to reduced therapy duration and improved patient outcomes. For instance, compared to traditional methods that continuously require physical equipment and materials, VR offers a reduction in the need for physical materials, which contributes to reducing operational costs (Villada Castillo et al., 2024). Furthermore, semi-immersive VR devices and commercial video game consoles involve savings compared to in-clinic interventions (Cano-de-la-Cuerda et al., 2024).

Serious games have the potential to reduce the burden on healthcare systems by allowing patients to participate in home-based rehabilitation, thereby alleviating the strain on limited healthcare facilities (Dereje et al., 2025). Home-based VR rehabilitation systems allow for independent training after an initial set-up, and reports show that therapist time per patient could be substantially reduced after implementing the intervention (Islam & Brunner, 2019). However, a significant financial burden to individual users remains an issue, as ongoing costs associated with technology operation include the purchase of accessories, consumables, and maintenance fees. To address the factors that contribute to technology underutilisation and to reduce the equity gap, researchers emphasize that a diverse range of stakeholders should be actively engaged and involved from the beginning of the development phase to reflect their values and perspectives (Koehle et al., 2022; Mitchell et al., 2023).

3.6 Governance, Regulation and Data Ethics

According to the reviewed literature, when off-the-shelf VR headsets are driven by software intended for medical purposes, they are legally classified as Software as a Medical Device (SaMD) or VR as a Medical Device (VRaMD) (Salisbury, 2021; Martjan et al., 2025). Specifically, software functions that perform patient-specific analysis or provide treatment recommendations are regulated; for instance, the US Food and Drug Administration (FDA) classifies interactive rehabilitation exercise devices as Class II medical devices (Salisbury, 2021). Consequently, developers must navigate stringent regulatory frameworks, such as the European Union's Medical Device Regulation (MDR). The MDR requires significant time, expertise, and financial resources to establish quality management systems (QMS), maintain technical documentation, and conduct clinical investigations to verify safety and performance (Martjan et al., 2025). Failure to integrate these medical device standards early in the design phase can lead to costly reworkings and delayed market access, particularly for start-ups driving innovation in the sector (Salisbury, 2021; Martjan et al., 2025).

Manufacturers bear the legal and ethical responsibility to systematically identify hazards, evaluate risks, and implement control measures throughout the software life cycle, often guided by international standards like ISO 14971 and IEC 62304 (Salisbury, 2021; Martjan et al., 2025). The literature highlights that the liability implications of AI, the Internet of Things (IoT), and robotics require developers to ensure transparent, accountable-by-design systems. Furthermore, "black-box" machine learning algorithms present unique liability and ethical challenges. Their lack of interpretability complicates the principles of informed consent, as it obscures how diagnostic or treatment decisions are generated. This lack of transparency can jeopardize patient safety and expose vendors to liability, particularly if the algorithms produce unsafe recommendations or exhibit algorithmic biases stemming from unrepresentative training datasets (Gerke et al., 2020).

Gamified rehabilitation systems and telerehabilitation platforms increasingly rely on the continuous monitoring of sensitive biometric data. Wearable and implantable biosensors collect diverse physiological and behavioral metrics, including electrocardiogram (ECG) data, electroencephalogram (EEG) signals, gait patterns via inertial measurement units (IMU), and emotional states through electrodermal activity (EDA) (Zendehbad et al., 2025). Similarly, the integration of eye-tracking technology provides direct information about users' cognitive processes and visual attention. Multiple studies indicate that the collection of such granular biometric data introduces profound structural issues regarding data security, user consent, and privacy (Korkmaz, 2026). Protecting this data in remote telerehabilitation environments necessitates robust cybersecurity measures, including continuous data encryption, firmware protection to prevent breaches, and strict compliance with legal frameworks such as the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA) (Zendehbad et al., 2025). Evidence suggests that without transparent user agreements and secure data processing, patient trust-which is vital for the successful integration of these systems into clinical practice-will erode. Furthermore, patients must be

protected against the unauthorized use of their data outside the doctor-patient relationship, which could negatively impact insurance premiums or employment opportunities (Gerke et al., 2020).

A major challenge identified across the reviewed interventions is the lack of interoperability between proprietary gamified rehabilitation platforms and public healthcare systems, such as Electronic Medical Records (EMRs). The literature reports that systemic incompatibilities are frequently driven by "vendor lock-in," a practice where proprietary ownership and closed ecosystems intentionally limit data exchange to ensure customer dependency. Vendors often guard information and charge cost-prohibitive fees for data exchanges or system modifications, viewing closed ecosystems as a powerful revenue and marketing tool. These proprietary models render patient data incompatible with third-party software, effectively creating isolated data silos that hinder the seamless transmittal of complete medical records to subsequent points of care (Carter et al., 2020).

To counteract the barriers imposed by proprietary ecosystems, researchers emphasize the necessity of adopting common data standards, such as the Fast Health Interoperable Resource (FHIR), which enables semantic interoperability and seamless information exchange across different healthcare providers. Furthermore, decentralized solutions, including blockchain technology, are proposed as methods to secure data integrity, provide tamper-proof audit trails, and return data ownership and control to the patients rather than centralized corporate authorities. By leveraging transparent, interoperable, and decentralized frameworks, the healthcare sector can mitigate the risks of data hoarding, ensure ethical data utilization, and facilitate a more equitable and efficient distribution of digital rehabilitation technologies (Zendehbad et al., 2025; Carter et al., 2020).

3.7 Economic and Public Health Implications

Across the reviewed literature, the economic impact of gamified rehabilitation is characterized by a transition toward decentralized, home-based care models that demonstrate potential for health system sustainability through cost-minimization and increased resource efficiency. Evidence indicates that while initial investments in technology are significant, these costs are often offset by long-term savings in clinical infrastructure and personnel time.

Studies comparing gamified digital interventions to traditional live exercises highlight a distinct contrast between high up-front costs and low longitudinal expenses. For instance, Farra et al. (2019) points out that while the development of VR training platforms requires substantial initial capital-with study reporting an upfront cost of $106,951.14 for software engineering and hardware-the long-term financial burden is significantly lower. Farra et al. (2019) demonstrated that the annual recurring costs for a VR system were only $1,069.51, a stark contrast to the $76,750.02 required annually for traditional live exercise training.

As a result, the cost per participant decreases significantly as the user base expands, allowing the initial investment to be amortized over a larger population. In comparative analyses, live training sessions often exhibit higher recurring costs due to the continuous need for professional staff and physical resources, whereas digital platforms maintain stable annual operational costs regardless of throughput.

Futhermore, evidence from the reviewed literature indicates that gamified rehabilitation provides a highly resource-efficient alternative to traditional clinical therapy by leveraging asynchronous training models. In a retrospective analysis of a high-dose neurorehabilitation program, it was reported that patients achieved an average cumulative training dose of 39.7 hours, with the vast majority of this training (82.2%) being delivered asynchronously

This shift in delivery significantly impacts personnel expenditure. Because direct therapist presence was required for only 17.8% of the total training dose, the total therapist costs per patient amounted to approximately US $338. In contrast, delivering the equivalent 39.7 hours through traditional in-clinic visits or synchronous teleconferencing-where 100% therapist presence is required-would result in costs of US $1,903 per patient (Arbuckle et al., 2025).

The implementation of gamified rehabilitation facilitates a model of decentralization, moving the point of care from inpatient clinics to the home environment. Research into home-based programs such as neurorehabilitation program mentioned in a Cost-Effectiveness vs. Cost-Shifting section, demonstrates that high-dose neurorehabilitation can be delivered efficiently using consumer-grade technology, achieving therapeutic goals with fewer in-person professional interventions (Arbuckle et al., 2025). Furthermore, teleconsultation and remote monitoring associated with these gamified systems have been shown to provide significant indirect cost savings for patients, particularly by reducing travel time and related expenses (Baek et al., 2025). Systematic reviews of post-acute care models further support that home-based rehabilitation can

achieve comparable clinical outcomes to inpatient care at a lower total cost to the healthcare system (Tung et al., 2021).

The adoption of digital health technologies is linked to improvements in the performance and workload management of healthcare providers. By automating routine monitoring and providing engaging, self-managed therapeutic content, gamified systems can alleviate the clinical load on practitioners, potentially increasing the overall capacity of the healthcare system (Jeilani & Hussein, 2025)

Despite these benefits, the long-term sustainability of these models is closely tied to the development of robust reimbursement frameworks. Current evidence suggests that outdated reimbursement structures act as a primary barrier to widespread adoption, even when the interventions demonstrate clinical rigor and potential for reducing overall healthcare expenditures (Reilly & Molnar, 2025; Sareban et al., 2025).

3.8 Clinical vs. Social Efficacy: Toward an Integrated Evaluation Framework

Evidence across the reviewed studies highlights a disparity between the achievement of physical clinical milestones and the broader restoration of social health. While gamified interventions yield consistent improvements in clinical parameters-specifically through increased muscle activation in response to system damping (Casanova et al., 2025) or robust pain reduction in chronic low back pain patients (Garofano et al., 2025)-these functional gains do not always translate linearly into an improved quality of life. As noted by Garofano et al. (2025), while sensor-based programs can achieve a 68.45% reduction in pain, short-term interventions like exergames may improve movement control without immediately reducing pain intensity. This gap underscores that functional recovery is distinct from psychological well-being. A gamification framework tailored to psychological rehabilitation has the potential to address the anxiety and social isolation common in chronic disease populations by enhancing motivation and self-efficacy (Fadzillah et al., 2025). Thus, while functional mastery of gamified tasks can occur rapidly, the intervention's success must also be measured by its ability to reduce negative emotions and promote long-term engagement (Fadzillah et al., 2025).

To bridge this gap, the literature supports a transition toward a comprehensive evaluation model. Beyond traditional clinical outcomes, such a model must include behavioral indicators, such as exercise self-regulatory efficacy and autonomous motivation, which are primary drivers of activity maintenance (Jiang et al., 2025). Furthermore, social indicators-including peer support and the mitigation of social stigma-are critical for fostering a "personalized and dynamic treatment experience" (Fadzillah et al., 2025).

Critically, an integrated framework must assess accessibility and equity impact, particularly concerning the sustainability and scalability of these tools. Current evidence is limited by considerable heterogeneity in intervention designs and a lack of long-term follow-up, which constrains conclusions about clinical scalability (Emaliyawati et al., 2025). Furthermore, a significant geographical bias exists; most research is conducted in high-income countries, leaving a sparse evidence base for settings where digital infrastructure and cultural engagement with gaming may differ significantly, potentially widening the gap in global health equity (Emaliyawati et al., 2025).

A holistic assessment of gamified rehabilitation requires the adoption of a socio-technical systems perspective, acknowledging that effectiveness is determined by the interaction between technical components and the user's environmental context. Analysis suggests that the current reliance on small sample sizes and short intervention durations in high-income settings overlooks the systemic challenges of scalability and cultural engagement (Emaliyawati et al., 2025). In remote settings, the success of a pulmonary rehabilitation intervention is contingent not only on its gamification elements but also on the patient's domestic support system and technical proficiency (Jiang et al., 2025). Similarly, robotic gamified frameworks are most effective when the technical design aligns with the user's lived experience and engagement needs (Casanova et al., 2025). Because digital infrastructure and cultural attitudes toward gaming vary globally, a socio-technical approach is essential to ensure that rehabilitation tools are adaptable to diverse social systems and do not fail due to a lack of contextual alignment (Emaliyawati et al., 2025).

4. Discussion

The synthesis of the reviewed literature indicates that the gamification of rehabilitation-the application of game-design principles in clinical contexts-has emerged as a promising strategy to enhance patient motivation and self-management (Nasri et al., 2025). However, the clinical efficacy of gamified systems remains contested; systematic evaluations in orthopaedic settings, for example, suggest that gamification does not currently demonstrate equivalence to conventional physical therapy in terms of functional outcomes (Evans et al., 2023). Instead, the primary utility of these systems appears to lie in their potential to improve patient adherence and behavioral engagement (Evans et al., 2023). To achieve this, the integration of gamification frequently relies on established psychological frameworks, most notably SDT, to structure motivational mechanics and foster sustained behavioral change (Ede, 2022; Patrick & Williams, 2012). Despite these potential benefits for engagement, the literature also exposes critical tensions inherent within this digital transition. These include the risk of behavioral dysregulation, the exacerbation of the digital divide, and ethical challenges related to data governance. By interpreting these findings through an interdisciplinary lens, this discussion delineates the behavioral, social, and technological implications of gamified rehabilitation, highlighting the necessity for carefully calibrated approaches to digital health innovation.

A central theme emerging from the reviewed studies is the psychological architecture underlying patient engagement in gamified rehabilitation. The transition toward internalized, autonomous regulation is consistently identified as a crucial factor in the maintenance of health behaviors (Simpson, 2021). This dynamic is best understood through the lens of SDT, which posits that therapeutic environments must satisfy the core psychological needs of autonomy, competence, and relatedness to foster optimal patient functioning and behavior internalization (Patrick & Williams, 2012; Simpson, 2021). The evidence suggests that when gamified interventions provide personalized goal-setting, they successfully scaffold autonomous motivation by allowing users to define their own targets (Nasri et al., 2025). Unlike extrinsically motivated behaviors-which rely on external pressures or rewards-autonomous regulation makes it more likely that health behaviors, such as physical activity and medication adherence, are maintained over time (Simpson, 2021). Furthermore, the integration of immediate feedback loops and progress indicators serves to explicitly reinforce patient competence (Nasri et al., 2025). Similar feedback mechanisms are utilized in specialized applications, such as BCI rehabilitation, where visual feedback provides users with essential self-awareness and real-time performance assessment (de Castro-Cros et al., 2020).

The psychological empowerment observed in the literature is deeply intertwined with neurobiological processes, particularly dopamine-driven reinforcement learning (Glimcher, 2011). Gamified environments exploit the dopamine reward prediction error by delivering unexpected virtual rewards, which trigger synaptic modifications in the frontal cortex and basal ganglia (Glimcher, 2011). This neurobiological mechanism is profoundly beneficial for conditions requiring high-intensity, repetitive movements, such as stroke recovery, where overcoming the phenomenon of "learned non-use" is a significant clinical hurdle (Ion et al., 2026). However, the reviewed studies caution against an over-reliance on purely extrinsic reinforcers within therapeutic design. While elements such as points and badges may provide the initial behavioral activation required to engage a patient, they risk inducing a "crowding out" effect, wherein superficial external rewards paradoxically diminish the patient's intrinsic drive (Ede, 2022; Nasri et al., 2025). To circumvent this detriment, the literature advocates for "meaningful gamification," wherein game mechanics are deeply and intrinsically integrated into the therapeutic clinical task. When interventions successfully intertwine clinical objectives with narrative transportation-such as framing repetitive physical exercises as a meaningful virtual quest-patients report lower perceived physical exertion, reduced psychological tension, and a heightened state of intrinsic interest (Ion et al., 2026; de Castro-Cros et al., 2020).

The efficacy of these motivational structures is heavily contingent upon their adaptability, highlighting the critical role of AI in mitigating the inherent limitations of static, "one-size-fits-all" rehabilitation approaches (Nasri et al., 2025; Attoh-Mensah et al., 2025). The evidence indicates that machine learning and AI-driven dynamic difficulty adjustments are essential for maintaining patients within their zone of proximal development, thereby facilitating the psychological state of "flow" (Tong et al., 2025). In this state of deep cognitive absorption, the therapeutic challenge is perfectly calibrated to the user's real-time skill level and biometric output, maximizing both subjective enjoyment and clinical performance. Crucially, the literature demonstrates that motivational profiles and the capacity for experiencing flow vary significantly across the human lifespan. While pediatric populations respond robustly to avatars and mini-games (Emaliyawati et al., 2025), and younger adults are frequently driven by competition and high-score systems, older adults tend to prioritize the perceived physical health benefits and the intrinsic joy of play (Subramanian et al., 2020). This

demographic divergence necessitates a highly nuanced approach to technological design. Because older populations often experience cognitive overload and frustration with complex graphical interfaces, the behavioral success of gamified rehabilitation relies on the careful calibration of system complexity to match the digital literacy, physical stamina, and motivational orientations of highly diverse patient populations (Tong et al., 2025; Nasri et al., 2025).

Beyond individual psychological impacts, the reviewed literature underscores the profound social implications of gamified rehabilitation, particularly its capacity to mitigate social isolation and foster meaningful digital connectivity (Wang et al., 2025; Lai et al., 2023). Immersive VR platforms and multiplayer exergames provide novel, highly customizable digital environments where patients can safely practice social cognition and collaborative physical exercises (Shah et al., 2023). For vulnerable populations, such as adolescents with physical disabilities or senior citizens experiencing restricted physical mobility, these virtual spaces serve as vital conduits for inclusive socialization. The use of digital avatars allows individuals who may feel marginalized or "out of place" in traditional social settings to interact freely, facilitating peer connections and the formation of friendships that frequently extend beyond the formalized therapeutic intervention (Lai et al., 2023). Furthermore, the integration of telerehabilitation systems equipped with haptic feedback, robotic exoskeletons, and real-time data visualization creates a powerful sense of "telepresence" (Liu et al., 2022). This digital bridge not only connects patients with their peers but also radically enhances the remote therapeutic alliance, allowing clinicians to dynamically monitor and adjust treatments while maintaining a supportive, autonomy-enhancing social environment directly within the patient's home (Norouzi-Ghazbi et al., 2025).

The architecture of social interaction within these platforms significantly dictates their ultimate behavioral outcomes, with the literature revealing a stark contrast between the psychosocial effects of competitive versus cooperative game mechanics. While competitive elements can induce short-term spikes in physical exertion and energy expenditure, they frequently generate adverse psychosocial effects, including increased stress, aggression, demoralization, and the rapid erosion of intrinsic motivation-particularly if a patient perceives their performance as vastly inferior to their peers (Shah et al., 2022; Marker & Staiano, 2015). Conversely, cooperative play, structured around joint tasks and collective digital rewards, consistently yields significantly higher intrinsic motivation, greater sustained physical exertion, and deeper social bonding (Shah et al., 2023). The reviewed studies suggest that for populations facing chronic conditions, such as stroke survivors, collaborative mechanics are vastly superior in promoting sustained adherence and long-term therapeutic engagement (Hadjipanayi et al., 2025). Furthermore, even in the absence of live human peers, the illusion of "co-presence" generated by artificial virtual agents can induce robust social facilitation, encouraging patients to persevere through physically demanding motor tasks (Hadjipanayi et al., 2025). Ultimately, the social support and communication inherent in collaborative gamification emerge as critical mediators of therapeutic adherence and behavioral maintenance.

Despite the clear social and motivational benefits, the integration of commercial gaming mechanics into digital healthcare introduces substantial risks concerning behavioral dysregulation and system dependency. The literature highlights that populations with specific developmental vulnerabilities, such as Attention-Deficit/Hyperactivity Disorder and Autism Spectrum Disorder, are particularly susceptible to the compulsive use of gamified systems (Kuo et al., 2024). When the satisfaction of core psychological needs becomes entirely tethered to a virtual environment, patients risk transitioning from high therapeutic involvement to pathological behavioral addiction, mirroring the clinical symptoms of Internet Gaming Disorder (Musetti et al., 2025). The utilization of variable reward schedules and micro-transaction economies within health platforms can trigger rapid reward-reinforcement loops akin to problem gambling (Mohd Tuah et al., 2021). Furthermore, the commercialization of digital health raises profound bioethical concerns, as generic gamification frameworks designed primarily to maximize user retention may prioritize objective physiological metrics-such as heart rate or interaction frequency-over the patient's holistic subjective well-being (Giunti, 2018). Consequently, there is a palpable tension between empowering patients with self-regulatory tools and inadvertently fostering a technological dependency wherein health-promoting behaviors completely cease outside the confines of the digital game (Nasri et al., 2025; Wang & Cheng, 2022).

The socio-technological promise of gamified rehabilitation is fundamentally constrained by the persistent reality of the digital divide, which the literature explicitly identifies as a super determinant of health (Bradway et al., 2026). The rapid expansion of digital health interventions threatens to exacerbate existing social inequalities if access remains limited strictly to the digitally engaged and economically privileged (Koehle et al., 2022). This disparity is particularly acute in low- and middle-income countries, where pervasive poverty, inadequate digital infrastructure, and a severe scarcity of clinical professionals represent immense

barriers to equitable healthcare (Dereje et al., 2025). Even within high-income nations, a second-level digital divide persists, characterized by vast disparities in digital literacy, particularly among older adults (Bradway et al., 2026). While gamified home-based systems theoretically democratize access to high-quality rehabilitation, they inherently require stable internet connectivity, adequate physical space, and ongoing technical support, effectively shifting the operational and financial burden from the clinic directly to the patient's household (Mitchell et al., 2023; Lai et al., 2023). The literature emphasizes that the failure to utilize inclusive, universal design principles frequently results in the alienation of less technologically proficient users, leading to program withdrawal, heightened frustration, and the subsequent widening of global health disparities.

Economically, the reviewed studies depict gamified rehabilitation as a disruptive force capable of fundamentally reshaping health system sustainability through decentralization and asynchronous care models. The financial architecture of these interventions is defined by substantial upfront capital requirements for software engineering and hardware procurement, juxtaposed against drastically reduced longitudinal operational costs (Farra et al., 2019). Traditional clinical rehabilitation inherently demands continuous, synchronous personnel expenditure, which scales linearly with patient volume and clinical visits. In contrast, digital platforms allow for the efficient amortization of initial investments over a broad population over time. Evidence robustly demonstrates that the deployment of asynchronous, high-dose neurorehabilitation significantly diminishes the necessity for direct, continuous therapist supervision, thereby drastically reducing the per-patient cost while simultaneously alleviating the clinical workload on overburdened healthcare systems (Arbuckle et al., 2025; Jeilani & Hussein, 2025). Furthermore, remote monitoring minimizes indirect patient costs, such as travel time and lost wages (Baek et al., 2025). However, the realization of these systemic economic benefits is currently stymied by outdated reimbursement structures. The literature indicates that the modernization of health policy and insurance pathways is a critical prerequisite to ensure the scalable adoption and equitable distribution of prescription digital therapeutics (Reilly & Molnar, 2025; Sareban et al., 2025).

As gamified rehabilitation platforms transition into mainstream clinical use, they intersect with highly complex regulatory and ethical frameworks governing Software as a Medical Device. The reviewed studies highlight the stringent requirements imposed by global regulatory bodies, such as the United States Food and Drug Administration and the European Union’s Medical Device Regulation, which mandate rigorous clinical investigations and comprehensive quality management systems (Salisbury, 2021; Martjan et al., 2025). A paramount concern within this regulatory landscape is the integration of AI and continuous biometric data collection. The utilization of wearable sensors-capturing electroencephalograms, eye-tracking, and electrodermal activity-generates vast repositories of highly sensitive personal information (Zendehbad et al., 2025). The literature underscores that the deployment of "black-box" machine learning algorithms compromises clinical transparency and fundamentally challenges the doctrine of informed consent, exposing vendors to significant liability (Gerke et al., 2020). Furthermore, proprietary ecosystems and "vendor lock-in" practices intentionally create isolated data silos, obstructing the seamless exchange of patient information across public healthcare infrastructures (Carter et al., 2020). To safeguard patient privacy, prevent algorithmic bias, and ensure ethical data utilization, the evidence strongly advocates for the adoption of decentralized digital architectures, such as blockchain technology, and the enforcement of universal interoperability standards like the Fast Health Interoperable Resource (Zendehbad et al., 2025; Korkmaz, 2026).

An overarching conceptual pattern identified in the literature is the frequent divergence between the attainment of objective clinical metrics and the realization of holistic social well-being. While gamified interventions consistently demonstrate the ability to induce rapid improvements in localized functional parameters-such as specific muscle activation or temporary pain reduction-these physical gains do not automatically translate into an enhanced quality of life or the alleviation of chronic psychological distress (Casanova et al., 2025; Garofano et al., 2025). The literature asserts that physical mastery of a gamified task is an insufficient marker of ultimate therapeutic success if the patient remains socially isolated or burdened by anxiety (Fadzillah et al., 2025). Consequently, there is an urgent need to transition toward comprehensive, integrated evaluation frameworks that elevate behavioral indicators, such as autonomous motivation and exercise self-regulatory efficacy, to the same level of importance as traditional clinical outcomes (Jiang et al., 2025). Furthermore, the mitigation of disease-related social stigma and the enhancement of peer support must be formally recognized as primary therapeutic endpoints, ensuring that digital rehabilitation addresses the patient as a socially embedded individual rather than merely a collection of isolated physical deficits.

The interpretation of these synthesized findings must be carefully contextualized within the explicitly identified limitations of the current evidence base. A primary limitation across the reviewed literature is the

considerable methodological heterogeneity in intervention designs, which severely complicates the cross-study synthesis of clinical efficacy and long-term behavioral outcomes (Emaliyawati et al., 2025). Furthermore, the existing literature is predominantly characterized by small sample sizes and relatively short intervention periods. This temporal limitation restricts the ability of researchers to evaluate the long-term sustainability of behavioral changes and the durability of intrinsic motivation once the initial novelty of the VR technology inevitably wanes. The reviewed studies also highlight a profound geographical and socioeconomic bias; the vast majority of the research has been conducted in high-income countries with established, robust digital infrastructures (Emaliyawati et al., 2025). This leaves a critical, glaring gap in understanding exactly how gamified rehabilitation functions in resource-constrained settings or among populations with vastly diverse cultural attitudes toward gaming and digital technology. Finally, the lack of a standardized, uniform terminology within the occupational therapy and digital health literature hinders the precise measurement and comparative analysis of complex psychosocial constructs (Zlotnik et al., 2023).

Based strictly on these identified gaps, future research must pivot toward rigorous, longitudinal study designs capable of assessing the long-term maintenance of health behaviors and the potential emergence of system dependency over extended multi-year periods. There is a critical, immediate need for large-scale, randomized controlled trials that purposefully incorporate diverse, socioeconomically varied populations to accurately test the cross-cultural validity and accessibility of gamified interventions, particularly within low- and middle-income countries (Dereje et al., 2025). Additionally, researchers should prioritize the development and validation of integrated evaluation frameworks that concurrently measure clinical efficacy, psychological well-being, and social connectivity using standardized terminology. Future investigations must also empirically address the ethical and regulatory dimensions of AI-driven personalization, seeking to establish transparent, interpretable machine learning models that support patient autonomy without obscuring clinical decision-making from practitioners. Finally, exploring the optimal design balance between extrinsic game mechanics and the genuine cultivation of intrinsic motivation remains a highly fertile ground for future interdisciplinary inquiry.

In conclusion, the gamification of rehabilitation represents a profound socio-technical evolution within the landscape of digital health innovation. The findings reviewed herein demonstrate that when digital technology is deliberately aligned with established psychological frameworks and neurobiological principles, it possesses the transformative potential to fundamentally redefine the patient experience (Nasri et al., 2025; Ede, 2022). This approach shifts rehabilitation from a passive, isolating, and often monotonous clinical obligation into an engaging, socially connected, and self-directed pursuit. However, this paradigm transition is not merely a matter of frictionless technological deployment; it requires a fundamental, interdisciplinary reimagining of rehabilitation design. A holistic, socio-technical systems perspective is absolutely imperative to ensure that digital interventions operate in harmony with the user's immediate environmental context, cultural background, and level of digital literacy. As global healthcare systems increasingly embrace decentralized, home-based care models to ensure economic sustainability, stakeholders must proactively dismantle the digital divide and navigate the profound ethical complexities of data governance and algorithmic transparency. Ultimately, the true promise of gamified rehabilitation lies not in the graphical sophistication of its immersive virtual environments, but in its unparalleled capacity to equitably empower individuals, foster meaningful social participation, and sustainably integrate health-promoting behaviors into the foundational fabric of daily life.

5. Limitations of the Review

While this review provides a comprehensive socio-technical synthesis of gamified rehabilitation, several inherent limitations must be acknowledged to contextualize the findings:

Narrative Nature of the Synthesis: As a narrative rather than a systematic review, the selection and interpretation of the literature were concept-driven and interpretative. Although the identification process was rigorous, it did not follow a strict systematic protocol (e.g., PRISMA). Consequently, a degree of selection bias may be present, and the results should be viewed as a qualitative synthesis rather than a statistical meta-analysis of clinical efficacy.

Methodological Heterogeneity of Primary Sources: The reviewed evidence base exhibits significant heterogeneity in terms of intervention designs, VR hardware, and specific gamification mechanics. This lack of standardization, combined with a frequent absence of uniform terminology in digital health and occupational therapy, complicates direct cross-study comparisons and hinders definitive conclusions regarding clinical scalability.

Sample Sizes and Temporal Constraints: A substantial portion of the analyzed research, particularly regarding emerging technologies like BCI and advanced AI personalization, relies on pilot studies with small sample sizes and relatively short intervention periods. This limits the ability to assess the long-term sustainability of behavioral changes or the durability of intrinsic motivation once the initial "novelty effect" of the technology diminishes.

Geographical and Socioeconomic Bias: There is a pronounced Western-centric bias in the current body of literature, with the vast majority of studies conducted in high-income countries with robust digital infrastructures. Therefore, the findings may have limited generalizability to low- and middle-income countries (LMICs), where digital literacy, cultural attitudes toward gaming, and economic barriers may fundamentally alter the patient-technology interaction.

Rapid Pacing of Technological Innovation: In the context of the 2025–2026 period, the digital health landscape is evolving at a pace that often outstrips the traditional academic publication cycle. Advancements in generative artificial intelligence (GenAI) and shifting regulatory frameworks may not yet be fully reflected in longitudinal clinical trials, which inherently operate on a slower time-scale for validation.

6. Conclusions

Gamified rehabilitation represents a transformative shift toward decentralized, home-based care, utilizing immersive technologies to enhance therapeutic adherence and functional outcomes through neurobiological reinforcement. Grounded in SDT, these interventions facilitate autonomous motivation and mitigate social isolation via telepresence and collaborative digital environments. However, the clinical utility of these systems remains complex, balancing substantial resource efficiency and cost-minimization against the risks of behavioral dysregulation and system dependency. The digital divide persists as a primary determinant of health, suggesting that without inclusive design, digital innovation may exacerbate existing health disparities. Furthermore, the classification of these platforms as Software as a Medical Device (SaMD) necessitates rigorous adherence to regulatory frameworks to address algorithmic opacity and data privacy concerns.

The long-term integration of gamified therapeutics into healthcare systems requires a socio-technical perspective that aligns technical architecture with the user’s environmental and cultural context. Future research must pivot toward large-scale, longitudinal studies to evaluate the durability of behavioral changes and the scalability of interventions across diverse socioeconomic settings. Achieving systemic sustainability will also depend on the modernization of reimbursement structures and the enforcement of interoperability standards to dismantle proprietary data silos. Ultimately, the significance of gamified rehabilitation lies in its capacity to equitably empower patients, fostering a transition from passive clinical protocols to self-directed, socially embedded health-promoting behaviors within contemporary digital ecosystems.

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