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Business Models and Delivery Structures Driving Adoption of Virtual Reality Stroke Rehabilitation in the United States

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ABSTRACT

Stroke rehabilitation in the United States faces major delivery challenges because many survivors require repetitive therapy that is long-term but experience barriers related to transportation, cost, therapist availability, and adherence. Virtual reality rehabilitation has become a potential solution because it can make therapy more engaging, measurable, and accessible beyond traditional rehabilitation settings. This narrative review examines literature on VR stroke rehabilitation, telerehabilitation, digital therapeutics, remote therapeutic monitoring, reimbursement, and healthcare innovation adoption. This review argues that adoption of VR stroke rehabilitation will depend less on the technology itself than on its fit with the economic and operational structure of the U.S. healthcare system. Clinic-based VR may remain useful for supervised rehabilitation, but home-based and hybrid models are more scalable because they can extend therapy beyond the clinic while preserving therapist oversight. Some technologies like consumer level VR hardware and remote monitoring systems make these delivery models more feasible. The main finding is that VR stroke rehabilitation is most likely to scale when clinical evidence, patient engagement, workflow integration, and reimbursement pathways align. Future adoption will depend on the care platforms and delivery methods, not just the VR technology.

1. INTRODUCTION

1.1 Stroke Rehabilitation Issue

Stroke is a major cause of disability long-term. It reduces motor function, independence and quality of life, and performance of daily tasks. More than 795,000 people in the United States have a stroke each year, creating a large population that may require extended rehabilitation services (Centers for Disease Control and Prevention [CDC], 2025). Upper-limb impairment is common after stroke, with research estimating that approximately 50% to 80% of acute stroke survivors experience upper-limb impairment and that many continue to have impairment months later (O'Flaherty et al., 2024). Rehabilitation is a long, repetitive, and extremely resource-intensive process for stroke survivors. Patients often need lots of practice with movements to promote neuroplasticity and motor recovery. Traditional rehabilitation depends heavily on direct patient interaction, access to specialized therapists, and regular attendance at clinics (Peng et al., 2021). This creates an accessibility problem for patients who may clinically need high-dose therapy, but healthcare systems can not reliably deliver enough sessions due to transportation barriers, cost, geography, and workforce limitations, (Cramer et al., 2019; Gunawan et al., 2025).

1.2 Emergence of VR Rehabilitation

Virtual reality rehabilitation was developed in part due to stroke therapy's repetition, survivors engagement, and feedback. VR is able to stimulate real-life tasks while providing multisensory feedback. It creates a structured environment where patients can practice movements in a safe and controlled way. (Rizzo & Koenig, 2017; Gunawan et al., 2025). In motor rehabilitation, VR turns repetitive therapy into goal oriented activities which improve motivation and adherence among patients.

VR can support motor rehabilitation, but the problem is that evidence is not uniformly dominant over conventional rehabilitation. VR programs can be used together with conventional therapy for motor rehabilitation in subacute stroke, while some trials found VR to be similarly effective rather than clearly superior (Peng et al. 2021). Home-based telerehabilitation produced motor gains comparable to in-clinic therapy when intensity and dose were matched (Cramer et al. 2019). For adoption, the finding is important because a technology does not need to demonstrate clear superiority in clinical outcomes to provide value. It may also be advantageous if it improves care delivery, expands access to rehabilitation services, enhances patient engagement, or increases the efficiency of existing treatment models.

1.3 Gap in Current Literature

The current literature on VR stroke rehabilitation focuses on clinical outcomes like Fugl-Meyer scores, which evaluates sensorimotor impairment such as upper-limb function, balance, mobility, and activities of daily living. Hospitals and rehabilitation centers do not adopt technology only because a study can work. Adoption depends on a myriad of factors such as reimbursement, workflow integration, staffing requirements, patient acceptance, and regulatory confidence. Organization innovation in healthcare is slowed by poor quality information and payment systems that reward volume more than value. (Cutler 2011). Healthcare delivery must be organized around patient value defined as outcomes relative to costs (Porter 2010). This creates a gap. VR stroke rehabilitation studies oftentimes ask whether VR improves recovery, but fewer analyses ask which business models and delivery structures make VR adoptable in real U.S. healthcare settings.

1.4 Purpose and Thesis

This literature review examines how reimbursement systems, delivery models, workflow design, and business incentives shape the adoption of VR stroke rehabilitation in the United States. This paper argues that the adoption of VR stroke rehabilitation will depend on how well it fits within existing healthcare systems. Technologies that combine clinical evidence, remote monitoring, therapist oversight, patient engagement, and reimbursable care models are more likely to achieve widespread adoption than standalone clinic-based devices.

2. METHODS

This paper uses a narrative literature review approach to examine the business models and delivery structures influencing the adoption of virtual reality stroke rehabilitation in the United States. A narrative review was appropriate because the purpose of this paper was not to calculate a pooled clinical effect size, but to synthesize evidence from multiple fields, including stroke rehabilitation, virtual reality, telerehabilitation, reimbursement policy, digital therapeutics, and healthcare innovation. This approach allowed the review to evaluate not only whether VR rehabilitation can improve patient outcomes, but also whether it can be implemented in real healthcare settings.

Sources were selected from peer-reviewed journal articles, randomized clinical trials, systematic reviews, meta-analyses, healthcare policy documents, professional practice advisories, and digital health adoption literature. I searched Google Scholar and Pubmed while also reviewing sources from specific journals, repositories, and policy websites including the Journal of Medical Intent Research, JSTOR, SSRN, Cochrane Library, JAMA Network, CMS, and APTA. The reviewed information included approximately 18 to 22 sources, depending on whether background theory and policy documents are counted separately from clinical studies, Most clinical and digital health sources were published between 2017 and 2025 while older sources were used for background theory, including healthcare innovation and technology acceptance theory. The search focused on literature related to virtual reality rehabilitation, stroke recovery, telerehabilitation, remote therapeutic monitoring, Medicare reimbursement, value-based healthcare, digital therapeutics, patient technology acceptance, and implementation barriers. Search terms included combinations of “virtual reality stroke rehabilitation,” “VR rehabilitation stroke,” “stroke telerehabilitation,” “home-based rehabilitation,” “remote therapeutic monitoring,” “digital therapeutics,” “Medicare reimbursement rehabilitation,” “value-based care,” “healthcare innovation adoption,” and “digital health adoption.”

Sources were included if they addressed at least one of the following themes: clinical evidence for VR or telerehabilitation in stroke rehabilitation, delivery models for rehabilitation services, reimbursement pathways for remote or digital rehabilitation, patient or clinician acceptance of digital health tools, workflow integration, healthcare innovation adoption, or value-based care. Studies focused only on technical development, engineering design, or prototype creation were excluded unless they also discussed clinical implementation, patient use, or rehabilitation delivery. Clinical trials and systematic reviews were used to establish the clinical plausibility of VR and telerehabilitation, while policy and healthcare management sources were used to analyze adoption incentives and business model viability.

The selected literature was analyzed thematically. Sources were first grouped into categories related to clinical effectiveness, delivery structure, reimbursement, provider incentives, patient acceptance, regulatory expectations, and implementation barriers. These categories were then compared to identify patterns explaining why some VR rehabilitation models may be more adoptable than others. Particular attention was given to the relationship between reimbursement and delivery model, since adoption in the U.S. healthcare system often depends on whether a technology can be integrated into existing payment and workflow structures.

Because this review focuses on adoption rather than clinical efficacy alone, evidence was interpreted through a healthcare management framework. Clinical sources were used to determine whether VR rehabilitation and telerehabilitation are viable forms of care, while business and policy sources were used to evaluate whether these models are financially and operationally sustainable. This method allowed the paper to connect clinical evidence with the practical conditions that shape healthcare innovation, including provider reimbursement, staffing burden, documentation requirements, patient usability, and scalability.

3. HEALTHCARE INCENTIVES AND ADOPTION THEORY

The adoption of VR stroke rehabilitation in the United States cannot be explained through clinical effectiveness alone. Healthcare organizations adopt technologies when those technologies fit payment incentives, produce measurable value, and can be integrated into clinical workflow. Organization innovation in healthcare is limited by two major barriers: public insurance systems that reward volume rather than value and inadequate information about care quality (Cutler 2011). This framework is directly relevant to VR rehabilitation because a rehabilitation clinic may be interested in VR systems, but interest alone does not create adoption. The technology must either increase reimbursable services, reduce costs, improve measurable outcomes, or solve a workflow problem.

This creates a central adoption problem for VR rehabilitation. A clinic-based VR system may improve engagement, but if it requires expensive hardware, staff training, room space, and therapist supervision without increasing reimbursement or improving measured outcomes, providers, who are also businesses, have little financial reason to adopt the care model. In a third-party fee-for-service reimbursement system, providers are often paid for billable encounters rather than for patient engagement, therapy adherence, or long-term functional improvement. Therefore, a VR system that improves motivation but does not connect to billing or documented outcomes may remain a research tool rather than a standard care model in rehabilitation facilities.

Value-based care shifts this logic. Porter defines healthcare value as patient outcomes relative to the cost of achieving those outcomes (Porter 2010). Under this framework, VR rehabilitation becomes more attractive when it improves recovery across the full stroke rehabilitation cycle, not merely one therapy session. For example, a VR system that helps patients continue therapy at home, tracks adherence, and gives clinicians usable data may support value-based goals more effectively than a device used only during supervised clinic visits. The business question is therefore not whether VR is clinically interesting, but whether it helps providers deliver better outcomes per dollar spent.

4. EMERGING TECHNOLOGIES ENABLING VR REHABILITATION DELIVERY

The adoption of virtual reality stroke rehabilitation is more feasible today because VR is no longer limited to expensive laboratory systems or specialized research equipment. Earlier clinical VR systems were often difficult to scale because they required advanced computers, custom hardware, and controlled research environments. More recent advances in VR-enabling technologies have made it possible to create low-cost, sophisticated, immersive, and interactive systems that can run on consumer-level computing devices (Rizzo & Koenig, 2017). This shift is important for adoption because it lowers the entry barrier for rehabilitation clinics, health systems, and home-based care models.

Modern VR systems also offer clinical functions that are directly relevant to stroke rehabilitation. Rizzo and Koenig (2017) explain that clinical VR can motivate, measure, and engage users by placing therapeutic activities inside interactive simulated environments. For stroke rehabilitation, this is valuable because patients often need repetitive movement practice, but repetition can become boring, tiring, or difficult to sustain. VR changes the patient experience by turning repetitive tasks into goal-directed activities while also allowing performance to be tracked. In business terms, this means VR is not only an engagement tool; it can become a data-generating rehabilitation platform.

The rise of sensors, wearable devices, and Internet of Things technology also makes VR rehabilitation more practical. Digital health now includes mobile health applications, telehealth, smart devices, sensors, wearables, health information technology, and cloud-based platforms (Dang et al., 2020). In rehabilitation, these technologies can track movement, exercise completion, patient response, and progress over time. Sagayam et al. (2020) describe IoT as a network of devices, sensors, software, and connections that allow physical objects to collect and transmit data. This matters for VR stroke rehabilitation because home-based and hybrid models require more than a headset. They require a way for therapists to know what the patient is doing outside the clinic.

Sensor-based feedback also supports a stronger clinical model. In traditional home exercise programs, therapists often rely on patient self-report, which can be incomplete or inaccurate. In a VR-supported system, motion sensors, controllers, wearable devices, or pressure sensors can help capture whether the patient completed the movement, how long the session lasted, and how performance changed. This makes remote rehabilitation more credible because it gives clinicians objective data rather than only verbal updates from the patient. It also supports reimbursement because remote therapeutic monitoring depends on documented therapy adherence and response.

Cloud-based data systems and interoperability make these models more adoptable at the health-system level. Digital health infrastructure increasingly depends on cloud computing, data sharing, APIs, and electronic health record integration (Abernethy et al., 2022). For VR rehabilitation, cloud-based systems can allow patient data from home sessions to be stored, analyzed, and reviewed by therapists. This makes hybrid care possible because the therapist does not need to be physically present for every repetition. Instead, the therapist can use collected data to identify whether the patient is progressing, struggling, or needs a change in the treatment plan.

Telehealth infrastructure also helps explain why VR rehabilitation is more feasible now than in the past. The expansion of telehealth and remote patient management has made patients, clinicians, and payers more familiar with care delivered outside traditional facilities (Abernethy et al., 2022). This does not mean VR rehabilitation will automatically be adopted, but it does mean that the healthcare system now has more experience with remote communication, remote monitoring, digital documentation, and hybrid care. These conditions make VR stroke rehabilitation easier to integrate than it would have been when care delivery was almost entirely clinic-centered.

However, emerging technology also creates new adoption challenges. Cloud-based systems raise concerns about privacy, data security, interoperability, and the digital divide. Abernethy et al. (2022) emphasize that digital health tools must be integrated into healthcare delivery systems and that cloud-based storage must protect privacy and data integrity. This is especially important for stroke rehabilitation because patients may be older, disabled, or less comfortable with digital tools. A technically advanced system will not scale if patients cannot access broadband, use the device confidently, or trust how their health data are handled.

Overall, emerging technologies make VR stroke rehabilitation feasible because they connect the virtual therapy environment to the real healthcare system. Consumer-level VR hardware lowers cost. Sensors and wearables make patient movement measurable. Cloud platforms allow data to move from the home to the clinician. Telehealth infrastructure supports remote communication. Digital therapeutics frameworks help position VR as a software-driven intervention rather than a recreational device. Together, these technologies make the strongest delivery model possible: a hybrid rehabilitation platform where patients complete high-repetition practice at home while therapists monitor progress, adjust treatment, and document outcomes. The importance of these technologies is not simply that they make VR more advanced. They make VR more adoptable.

5. DELIVERY MODELS OF VR STROKE REHABILITATION

5.1 Clinic-Based VR Therapy

Clinic-based VR therapy is the most traditional delivery model in the market because it keeps the technology inside the rehabilitation facility and allows therapists to supervise patients directly. This model has clear clinical advantages. Therapists can monitor safety, correct movement patterns, adjust task difficulty, and help patients who are unfamiliar with VR equipment. This is especially important because VR rehabilitation can involve dizziness, nausea, fatigue, visual discomfort, or difficulty navigating a digital environment. In a preliminary preprint study, Arif et al. (2025) found that post-stroke patients generally perceived VR-based rehabilitation positively, while also emphasizing the need to monitor side effects and adjust session duration and intensity.

However, clinic-based VR has weaker scalability. It does not solve the transportation problem, therapist shortage, or low therapy-dose problem that limits conventional stroke rehabilitation Many stroke patients receive suboptimal rehabilitation because of cost, transportation difficulty, regional shortages of rehabilitation care, and poor adherence to assignments (Cramer et al. 2019). If a VR system remains inside clinics, it may improve the quality of individual sessions but still fail to expand access for patients who cannot consistently attend therapy appointments.

Clinic-based VR is most likely to succeed in specialized rehabilitation centers, academic medical centers, or outpatient clinics that already have enough patient volume and therapist expertise to justify equipment purchase. Its business model is likely to depend on institutional purchasing, leasing, or software subscriptions. The weakness of this model is that it treats VR as a capital investment rather than a scalable care-delivery structure.

5.2 Home-Based Telerehabilitation

Home-based telerehabilitation is more disruptive because it changes where rehabilitation happens. Instead of requiring every session to occur in the clinic, patients can complete therapy at home using digital tools, connected devices, and remote clinician support. Cramer et al. (2019) provide strong evidence for the feasibility of this model. In a randomized noninferiority trial of 124 stroke patients across 11 U.S. sites, participants received 36 matched therapy sessions either at home through telerehabilitation or in a clinic. Telerehabilitation produced motor gains comparable to in-clinic therapy, and adherence was slightly higher in the telerehabilitation group.

This evidence shifts the adoption argument for VR therapy. Home-based rehabilitation does not need to demonstrate substantial superiority over in-clinic therapy to produce value. If it achieves comparable clinical outcomes while reducing transportation barriers and increasing access to care, it may represent a compelling option for providers, payers, and patients. From a healthcare delivery and economic perspective, the combination of noninferior outcomes and enhanced accessibility may be sufficient to support broader implementation and adoption. The evidence also had limits. Laver et al. (2020) found that telerehabilitation evidence remains low to moderate in quality with variation across studies and limited cost-effectiveness data. This means that home-based VR rehabilitation is promising but not fully settled. For payers and providers, the missing economic evidence is crucial for adoption. A system may work clinically, but the adoption will be slower if it cannot show whether it saves money, reduces downstream complication , improves adherence, or produces measurable functional gains.

5.3 Hybrid Monitoring Model

The hybrid model is likely the strongest adoption pathway because it combines the supervision of clinic-based care with the scalability of home-based rehabilitation. In this model, patients attend some in-person therapy sessions but also complete VR-guided exercises at home. The platform tracks adherence, therapy response, and functional progress while therapists review the data and adjust the care plan.

This model aligns closely with remote therapeutic monitoring. The American Physical Therapy Association (APTA) explains that physical therapists can bill RTM codes under Medicare and that RTM includes monitoring therapy adherence and therapy response under an active plan of care. This is critical because it gives VR rehabilitation a possible reimbursement pathway. A VR platform that only delivers exercises may be useful, but a VR platform that also collects therapeutic data, supports documentation, and allows therapist management becomes more financially viable.

The hybrid model also addresses a clinical limitation of fully remote care. Gunawan et al. (2025), in a preprint systematic review and meta-analysis, found promising results for FMA-UE and Wolf Motor Function Test outcomes, but weaker or less consistent findings for fine-motor and dexterity measures. This suggests that home-based VR may be especially appropriate for gross motor practice and high-repetition movement training, while fine motor rehabilitation may still require more direct therapist supervision. A hybrid system can sort patients by need. Lower-risk or gross-motor tasks can be practiced remotely while more complex motor retraining can remain supervised.

Model	Supervision	Scalability	Reimbursement Pathway	Main Weakness
Clinic-Based VR	High therapist supervision	Low to moderate	Traditional therapy visit billing	Does not solve transportation or therapy dose barriers
Home-based Telerehabilitation	Remote therapist support	High	Telehealth or home exercise support, depending on payer	Required patient technology access, safety screening, and support
Hybrid Monitoring Model	Mixed in-person and remote oversight	Moderate to high	RTM plus therapy billing when requirements are met	Needs direct trails and workflow validation

6. REIMBURSEMENT AND BUSINESS MODELS

Without a sustainable reimbursement mechanism, VR rehabilitation is at risk of remaining a promising innovation confined to pilot programs and limited clinical trials. The RTM code structure is particularly significant because it permits reimbursement for specific remote monitoring and treatment management activities when established documentation and clinical requirements are satisfied. According to APTA, RTM codes encompass services such as patient setup and education, device supply, and treatment management time. For VR-based stroke rehabilitation, this suggests that successful business models should be structured around the delivery and monitoring of therapeutic care rather than the provision of hardware alone.

This changes the kind of companies that are likely to succeed. A company that sells only VR headsets or games may struggle because providers still need to solve billing, documentation, patient onboarding, and clinical monitoring. A stronger model would package the VR program with therapist dashboards, adherence tracking, outcome reporting, patient education, technical support, and documentation tools. In this structure, the product is not just the headset; the product is the reimbursable care pathway.

Digital therapeutics literature supports this shift.Dang et al. (2020) define digital therapeutics as evidence-based software-driven interventions used to prevent, manage, or treat disease, either independently or alongside other therapies. This framing fits VR rehabilitation better than a simple medical-device model. Stroke rehabilitation VR is not merely equipment; it is a software-enabled intervention that must show evidence, usability, safety, and integration into care delivery.

The most viable business model is therefore likely to be a hybrid platform model. Clinics may pay for access to the software, devices, analytics, and support services, while therapists use RTM or related therapy billing pathways to manage patients over time. This model is more adoptable because it aligns the interests of all major stakeholders. Patients gain convenience and engagement, therapists gain data and continuity between visits, providers gain a billable care model, and payers gain a potential mechanism for improving outcomes without relying entirely on in-person therapy volume.

7. BARRIERS TO ADOPTION

7.1 Workflow Integration

Workflow integration is one of the most important barriers to the adoption of VR stroke rehabilitation because a technology that improves therapy outcomes can still fail if it disrupts clinical practice. In a rehabilitation setting, therapists must evaluate patients, choose appropriate exercises, supervise movement quality, document progress, communicate with patients, and meet billing requirements. If a VR system adds extra steps to this process without reducing another burden, it becomes a workflow problem rather than a solution.

This barrier is especially important for VR rehabilitation because stroke therapy is not simply a set of exercises. Therapists often need to assess movement quality, compensation patterns, fatigue, pain, balance, safety, and functional carryover into daily life. **Laver et al. (2020)** note that one of the challenges of telerehabilitation is that therapists may be unable to conduct assessments or interventions that are normally hands-on, such as direct assessment of muscle strength. This means that home-based VR systems cannot simply transfer clinic activities into a headset. They must redesign therapy tasks so patients can complete them safely and so therapists can still make clinically meaningful decisions from a distance.

The adoption implication is clear: VR systems that only provide games or exercises are less likely to scale than systems that fit the therapist's workflow. A successful VR rehabilitation platform must help therapists prescribe exercises, track patient adherence, monitor response, identify problems, and document progress. This is where remote therapeutic monitoring becomes important. APTA explains that RTM codes require documentation of data gathered from the device, patient or caregiver interaction, and decisions that affect the treatment plan. Therefore, workflow integration is not only a convenience issue; it is tied directly to reimbursement. If the platform does not make monitoring and documentation easy, the provider may not be able to justify the time or bill appropriately.

Digital health literature supports this point. Abernethy et al. (2022) argue that early digital health tools often automated existing paper processes rather than redesigning care delivery and payment (Abernethy et al. 2022). This is directly applicable to VR stroke rehabilitation. The strongest systems will not just digitize therapy exercises. They will redesign rehabilitation delivery by allowing patients to practice more at home while therapists use data to target their limited time more efficiently.

7.2 Patient and Clinician Acceptance

Patient and clinician acceptance are also major adoption barriers. A VR rehabilitation system may be clinically promising, but if patients find it uncomfortable, confusing, or exhausting, adherence will fall. Similarly, if clinicians do not trust the data, believe the exercises are clinically meaningful, or feel the system makes their work harder, they are unlikely to use it consistently.

Technology-acceptance theory suggests that perceived usefulness, perceived ease of use, social influence, facilitating conditions, and user confidence shape whether people adopt new technologies (Davis, 1989; Venkatesh et al., 2003). This is especially important for stroke rehabilitation because stroke survivors may have motor impairments, cognitive challenges, visual deficits, fatigue, or low confidence with technology. A VR system may look engaging to developers but still be difficult for patients who are recovering from neurologic injury.

Arif et al. (2025) provide useful evidence because the study directly examined safety and user perception of VR-based rehabilitation in post-stroke patients. Participants rated the VR rehabilitation positively in terms of effectiveness, ease of use, and satisfaction, and the study found minimal vital-sign changes except for increased heart rate. However, the study also highlights why adoption cannot rely only on enthusiasm. Side effects such as motion sickness, dizziness, fatigue, nausea, visual discomfort, and problem-solving difficulties must be addressed before widespread clinical use.

This creates a more nuanced adoption argument. Patient acceptance is not simply about whether patients like VR. It is about whether the technology can be used repeatedly, safely, and independently enough to support long-term rehabilitation. For home-based models, usability becomes even more important because a therapist may not be physically present to troubleshoot the system. For clinic-based models, clinician acceptance may matter more because therapists decide whether VR adds enough value to justify using appointment time, room space, and staff attention.

Therefore, VR companies and providers must treat acceptance as part of the business model. Training, onboarding, technical support, adjustable difficulty, short session options, safety screening, and clear patient instructions are not optional extras. They are adoption infrastructure.

7.3 Regulatory and Evidence Requirements

Regulatory and evidence expectations create another barrier because healthcare organizations and payers need confidence that VR rehabilitation is safe, effective, and appropriate for specific patient populations. Many VR studies show promise, but adoption in healthcare requires more than promising pilot data. Hospitals and payers need evidence that the technology works for the intended population, in the intended setting, and under realistic clinical conditions.

Birckhead et al. (2019) argue that clinical VR research needs a structured development process. Their VR-CORE framework separates VR studies into three stages: VR1 studies focused on content development with patient and provider input, VR2 studies focused on feasibility, acceptability, tolerability, and early efficacy, and VR3 studies using randomized controlled designs to test outcomes against a control condition. This framework matters because it shows why many VR systems do not move smoothly from research to adoption. A system may have a clever design but lack feasibility testing, or it may show early usability but lack randomized evidence.

The evidence barrier is especially important for stroke rehabilitation because different patients need different levels of supervision. A mildly impaired chronic stroke survivor may be able to use a home-based VR system safely, while a patient with severe balance issues, neglect, cognitive impairment, or high fall risk may need direct supervision. If studies do not define patient selection criteria clearly, providers may be unsure which patients are appropriate candidates.

Gunawan et al. (2025) also show why outcome specificity matters. Their review found that VR telerehabilitation showed promising results for upper-extremity measures such as FMA-UE and Wolf Motor Function Test, but evidence was weaker or less consistent for other measures such as Box and Blocks Test, Nine Hole Peg Test, and Chedoke Arm and Hand Activity Inventory. This means VR adoption should not be presented as a universal solution for all motor recovery. It may be more compelling for certain outcomes, especially high-repetition gross motor practice, while fine motor dexterity and complex functional tasks may still require closer therapist involvement.

For adoption, the regulatory and evidence lesson is that VR companies must be specific. They should not claim that VR "improves stroke rehabilitation" in a broad way. They should identify which patients, which impairments, which setting, which outcome measures, and which delivery models are supported by evidence. Specific evidence creates payer confidence, clinician trust, and clearer implementation.

Source	Design	Setting or Sample	Main Finding	Main Limitation
Cramer et al. (2019)	Randomized clinical trial	124 stroke patients across 11 U.S. sites	Home telerehabilitation produced comparable motor gains to in-clinic therapy	Not a VR-specific business model stud
Laver et al. (2020)	Cochrane review	Stroke telerehabilitation studies	Telerehabilitation may support access and comparable outcomes	Evidence quality and cost-effectiveness data limited
Peng et al. (2021)	Meta-analysis	Subacute stroke VR rehabilitation studies	VR may support motor recovery when combined with conventional therapy	Clinical outcomes focus, not adoption economics
Gunawan et al. (2025)	Preprint systematic review and meta-analysis	VR telerehabilitation studies	Stronger findings for some upper-extremity outcomes than fine-motor outcomes	Preprint, not peer reviewed
Arif et al. (2025)	Preliminary preprint study	Post-stroke VR users	Positive user perception, but side effects and usability matter	Preliminary and not peer reviewed
Birckhead et al. (2019)	Methodology Framework	VR clinical-trial guidance	VR needs staged design, feasibility,	Not stroke-specific

			and RCT validation	

7.4 Cost and Infrastructure

Cost and infrastructure are adoption barriers because VR rehabilitation requires more than the headset itself. Providers must consider hardware, software licensing, maintenance, infection control, patient training, clinician training, technical support, internet access, cybersecurity, data privacy, and integration with electronic health records. For home-based models, there are additional costs related to shipping devices, replacing damaged equipment, troubleshooting connectivity issues, and supporting patients who may not be comfortable with technology.

Laver et al. (2020) note that telerehabilitation may reduce travel time and potentially allow clinicians to fit more consultations into a day, discharge patients earlier, or increase therapy dose without increasing face-to-face supervision. However, the review also warns that telerehabilitation services may be expensive to establish because of equipment, training, and ongoing technical support. This creates the central cost tension: telerehabilitation may reduce some delivery costs, but only after an organization absorbs the startup and infrastructure costs.

CMS policy also shows that the economics of remote monitoring are still evolving. CMS (2025) discusses difficulties in valuing remote therapeutic monitoring supply and equipment inputs, including concerns about how to accurately account for software and digital tools in payment methodology. This matters because VR rehabilitation platforms depend on the same unresolved economics: software and device costs are real, but payment systems are still adapting to how digital therapeutic infrastructure should be valued.

Real-world telemedicine evidence also complicated the assumption that remote care automatically reduces spending. Nakamoto et al. (2024) found that Medicare patients in high telemedicine health systems had slightly more outpatient visits, fewer non-COVID emergency department visits, higher annual spending per patient, and no clear differential change in hospitalizations or preventive care. This suggests that remote rehabilitation models may improve access and continuity, but they still need direct cost-effectiveness evidence before providers or payers can assume financial savings.

The adoption implication is that cost-effectiveness evidence will become increasingly important. Providers may be willing to adopt VR systems if they can show improved adherence, reduced missed appointments, earlier discharge, better functional outcomes, or increased billable monitoring. Without this evidence, VR may be seen as an expensive add-on. The systems most likely to survive will be those that can prove not only clinical benefit, but operational and financial value.

8. OPPORTUNITIES AND MARKET GROWTH

8.1 Remote Care Expansion

The strongest opportunity for VR stroke rehabilitation is remote care expansion. Traditional stroke rehabilitation depends heavily on in-person visits, but many patients face transportation limitations, regional shortages of rehabilitation specialists, cost barriers, and long-term unmet needs. Cramer et al. (2019) notes that many patients receive suboptimal rehabilitation doses because of cost, travel difficulty, regional shortages of rehabilitation care, and poor adherence. This creates a delivery gap that VR-supported telerehabilitation is designed to address.

Cramer et al. (2019) also provide important evidence for scalability. In their randomized trial, home-based telerehabilitation was not inferior to in-clinic therapy for arm motor recovery, and adherence was slightly higher in the telerehabilitation group. This does not mean home-based therapy should replace all clinic therapy. Instead, it shows that at least some stroke rehabilitation can be delivered outside the clinic without sacrificing outcomes. For providers and payers, this is a major adoption opportunity because comparable outcomes with improved access can justify new care models.

Laver et al. (2020) authors expand this argument by explaining that telerehabilitation may be especially helpful for rural and remote patients, people with limited mobility, and patients who lack access to stroke-specialized rehabilitation teams. This makes VR telerehabilitation not just a technology trend, but a potential access strategy. In market terms, the opportunity is not simply selling to rehabilitation centers. It is extending rehabilitation into homes, rural areas, post-discharge care, and long-term recovery.

8.2 Value-Based Care Alignment

VR stroke rehabilitation also aligns with value-based care because it has the potential to increase therapy dose, improve adherence, collect outcomes data, and reduce avoidable costs. Porter defines value as patient outcomes relative to cost, which means the most important question is not whether VR is novel, but whether it improves recovery efficiently across the full care cycle (Porter 2010).

This framing favors hybrid care models. A standalone clinic-based VR device may improve an individual session, but a hybrid VR model can extend care beyond the visit. If the system tracks adherence, performance, symptoms, and therapy response, it can help providers identify which patients are progressing and which patients need more support. This supports value-based care because it uses data to allocate clinician time more efficiently.

Remote therapeutic monitoring also strengthens the value-based argument**.** APTA explains that RTM codes can be used to monitor therapy adherence and therapy response under an active plan of care. This matters because it creates a financial structure around ongoing patient management rather than only in-person visits. In a value-based model, the provider has an incentive to improve recovery and avoid unnecessary utilization. In a fee-for-service model, RTM can still help because it creates a billable pathway for remote management. VR platforms that support RTM documentation are therefore better positioned for adoption than platforms that only provide isolated exercises.

8.3 Future Healthcare Delivery Trends

The future of stroke rehabilitation is likely to become more decentralized, data-driven, and hybrid. Digital health is already changing healthcare by supporting remote monitoring, telemedicine, self-management, and care coordination. Abernethy et al. (2022) describe digital health as including telehealth, consumer-facing applications, sensors, data infrastructure, and tools that can support off-site patient management and self-management (Abernethy et al. 2022). VR stroke rehabilitation fits into this larger movement because it turns therapy into a measurable, interactive, and potentially home-based intervention.

However, decentralization does not mean eliminating clinicians. The stronger prediction is that rehabilitation will shift toward a distributed model: patients complete more practice outside the clinic, while therapists use data to guide decision-making, personalize treatment, and intervene when needed. This fits the evidence better than a fully automated model. **Cramer et al. (2019)** emphasizes the importance of maintaining licensed therapist involvement during telerehabilitation, and **Laver et al. (2020)** notes that some interventions remain difficult to deliver remotely because they require hands-on assessment or modification.

The market opportunity is therefore strongest for companies that build clinical platforms rather than isolated VR products. Future systems will likely combine VR exercises, sensor-based movement tracking, therapist dashboards, patient education, progress reports, RTM documentation, technical support, and outcomes analytics. These systems are more likely to be adopted because they solve multiple problems at once: patient engagement, access, documentation, reimbursement, and outcome measurement.

9. DISCUSSION

The evidence suggests that VR stroke rehabilitation adoption will be shaped by the interaction between clinical value, reimbursement, and workflow fit. The central issue is not whether VR can support stroke recovery. The literature already shows that VR and telerehabilitation can be clinically plausible, especially for motor rehabilitation and home-based access. The more important question is why some VR systems will be adopted while others remain stuck in research pilots or small specialty clinics.

Clinic-based VR systems may succeed when the patient population requires close supervision, when therapists need to monitor movement quality directly, or when the clinic has enough patient volume to justify the equipment. However, this model has limited scalability because it does not fully address transportation, long-term access, or therapy dose. It may improve the therapy experience, but it does not fundamentally change the delivery structure.

Home-based VR telerehabilitation offers greater scalability because it moves therapy into the patient's living environment. Cramer et al. (2019) supports this model by showing that home-based telerehabilitation can produce motor gains comparable to in-clinic therapy. However, fully remote models also face barriers: patients may need technical support, some assessments are difficult without hands-on care, and certain impairments may require therapist supervision.

For this reason, this review infers that the hybrid monitoring model is the strongest adoption pathway, based on the combined evidence on clinic-based supervision, home-based access, remote monitoring, reimbursement, and workflow fit. It solves the largest number of problems at once. It preserves therapist oversight, expands therapy beyond the clinic, supports patient adherence, creates measurable data, and may connect to RTM reimbursement. This model also responds to the evidence limitations. Because Gunawan et al. (2025)found stronger evidence for some upper-extremity outcomes than others, hybrid care allows providers to match the delivery model to the patient's impairment. Patients who need high-repetition gross motor training may do more at home, while patients needing fine motor retraining, safety supervision, or hands-on assessment may remain more clinic-based.

The business model that follows from this analysis is clear. The most adoptable VR stroke rehabilitation products will not be marketed simply as devices. They will be marketed as care-delivery platforms. The winning model will include clinically validated exercises, patient selection guidance, therapist dashboards, adherence monitoring, outcome measurement, documentation support, RTM compatibility, training, and technical support. In other words, the business is not the headset. The business is the rehabilitation pathway wrapped around the headset.

This also explains why some VR systems fail. A product can be engaging but fail because it lacks reimbursement. It can be clinically promising but fail because it increases therapist workload. It can have strong software but fail because patients cannot use it independently. It can collect data but fail because the data are not clinically useful or easy to document. Adoption occurs when the technology, care model, and payment model fit together. Without that fit, VR remains a shiny tool sitting outside the actual machinery of healthcare delivery.

However, this conclusion remains a reasoned synthesis rather than a directly tested finding. Future research should test hybrid VR stroke rehabilitation in trials that measure clinical outcomes, adherence, therapist workload, patient satisfaction, reimbursement feasibility, and total cost of care.

10. LIMITATIONS

This paper is a narrative review rather than a systematic review, so it does not include formal quality scoring, meta-analysis, or a complete search of all available literature. Because the focus is on business models and delivery structures, some clinically focused trials were used mainly to support analysis of adoption rather than to evaluate clinical efficacy in detail.

Another limitation is that reimbursement policies for telehealth, remote therapeutic monitoring, and digital therapeutics continue to evolve. APTA (2025) explains that physical therapists can bill RTM codes under Medicare, but coverage and documentation requirements may vary across payers. This means that conclusions about financial viability may change as Medicare and commercial insurance policies develop.

A third limitation is that some VR stroke rehabilitation evidence remains preliminary. Some studies have small sample sizes, and some newer sources are preprints that have not yet been peer reviewed. Laver et al. (2020) also notes that telerehabilitation evidence is still low to moderate in quality and that cost-effectiveness evidence remains limited. This limits the ability to make definitive claims about long-term financial impact.

A further limitation is that no included study directly tests the hybrid monitoring model as a full care-delivery pathway. The argument that hybrid delivery is the most adoptable model is therefore an inference from the strengths and weaknesses of clinic-based and home-based models, rather than a conclusion proven by direct comparative evidence.

Finally, this review focuses mainly on the United States, where Medicare policy, private insurance, provider incentives, and rehabilitation delivery structures create a specific adoption environment. Findings may not fully apply to countries with different healthcare financing systems or national rehabilitation programs.

11. CONCLUSION

Virtual reality stroke rehabilitation has meaningful clinical and business potential, but adoption in the United States will depend on more than clinical promise. The strongest evidence does not support a simple story that VR will automatically replace conventional therapy. Instead, the literature suggests a more realistic conclusion: VR will be adopted when it fits the economic and operational structure of rehabilitation care.

Clinic-based VR may remain useful for supervised therapy, especially for patients who need close monitoring. Home-based telerehabilitation expands access and can produce outcomes comparable to in-clinic therapy for some patients. However, the hybrid monitoring model is likely the most adoptable structure because it combines remote practice, therapist oversight, adherence tracking, patient engagement, and possible RTM reimbursement.

The future of VR stroke rehabilitation will be shaped by business model design. Companies and health systems that treat VR as a standalone device will face major barriers related to cost, workflow, evidence, and reimbursement. Companies that build integrated care platforms will be better positioned to scale. Future research should focus not only on whether VR improves motor function, but also on which delivery models improve adherence, reduce cost, support therapist workflow, meet reimbursement requirements, and produce measurable long-term outcomes. In U.S. healthcare, the technology that wins is rarely the flashiest one. It is the one that fits the system well enough to become routine care.

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