DOI: 10.66069/ojspub.27450769

Immersive Virtual Reality in Post-Intensive Care Recovery: A Theory-Informed Narrative Review

Zhenti Cui*, Xiaojie Hou, Xiaoxiao Lin, Yaru Feng, Yi Zhang

School of Medicine, Sias University, Zhengzhou, China
Correspondence Author, zhenti.cui@sias.edu.cn

Abstract: ***Background:*** *Survivors of critical illness may experience persistent physical, cognitive, and psychological problems collectively described as post-intensive care syndrome (PICS). Immersive virtual reality (VR) has attracted interest as a flexible non-pharmacological medium during and after intensive care, but the clinical meaning of "VR intervention" remains unclear because relaxation, education, psychological therapy, and rehabilitation applications operate through different mechanisms.* ***Objective:*** *To develop a clinically grounded account of how immersive VR might support recovery from critical illness, clarify the mechanisms that connect VR design to PICS-related targets, and identify conditions required for safe nursing and rehabilitation practice.* ***Approach:*** *This theory-informed narrative review integrates foundational PICS literature with relevant empirical reports of head-mounted immersive VR in adult intensive care and post-ICU recovery. Literature was selected for conceptual and clinical relevance rather than comprehensive coverage. No formal screening counts, study-level data extraction, risk-of-bias assessment, or quantitative synthesis were undertaken.* ***Main discussion:*** *VR is better understood as a configurable therapeutic medium than as a single intervention. Sensory modulation and attentional capture may support short-term calm and comfort; presence, explanation, and memory reconstruction may contribute to orientation and psychological processing; and embodiment, feedback, and task structure may promote active rehabilitation. These pathways map onto psychological, cognitive/sleep, and physical PICS domains, but they are moderated by alertness, delirium risk, fatigue, sensory and motor capacity, content, dose, timing, staff support, and technical burden. Existing clinical studies are consistent with feasibility and possible short-term benefit in selected patients, while evidence for prevention or treatment of persistent PICS remains insufficient.* ***Conclusions:*** *Immersive VR should not be presented as an established treatment for PICS. Its value depends on matching a defined therapeutic target with appropriate content, interaction, dose, clinical timing, and supervision. A theory-informed framework can help nurses, therapists, and researchers distinguish low-intensity comfort applications from psychologically or physically demanding interventions and select outcomes that correspond to the proposed mechanism.*

Keywords: Critical illness, Intensive care unit, Post-intensive care syndrome, Virtual reality, Rehabilitation, Narrative review.

1. Introduction

Survival after critical illness does not necessarily restore a person's previous health. New or worsened weakness, reduced mobility, cognitive impairment, anxiety, depression, post-traumatic stress symptoms, sleep disturbance, and difficulty returning to family or social roles can continue long after organ support has ended. The term post-intensive care syndrome (PICS) was introduced to bring these physical, cognitive, and mental health problems into a common recovery framework [1]. PICS is not a single disease with one cause or one trajectory. It is a multidomain description of problems that arise from the interaction of pre-existing vulnerability, critical illness, ICU exposures, and the conditions of recovery [2]. In a cohort of 406 survivors, problems in at least one PICS domain were common at both 3 and 12 months, although the pattern and co-occurrence of impairments varied substantially between individuals [3,4]. This heterogeneity is important: an intervention that briefly reduces anxiety at the bedside cannot automatically be assumed to improve cognition, physical function, or long-term quality of life.

Clinical efforts to reduce avoidable harm during intensive care already emphasize pain management, light and appropriate sedation, delirium assessment, sleep, early mobility, and family engagement [5]. The ABCDEF bundle reflects the same recovery-oriented principle: patients should be treated as active persons whose cognition, mobility, comfort, and relationships matter during critical illness, not only after discharge [6]. Immersive virtual reality (VR) has emerged within this broader movement toward non-pharmacological and person-centred care. A head-mounted display can substantially replace the immediate visual environment with a computer-generated or recorded scene. Depending on the program, the patient may passively view nature, follow guided breathing, receive an explanation of ICU events, interact with a therapeutic scenario, or perform goal-directed movements in a virtual space.

These uses are often discussed as though they represent one intervention. They do not. A stationary beach scene shown for ten minutes is conceptually closer to a relaxation aid; an ICU tour is an educational and memory-processing tool; therapist-led exposure addresses trauma-related responses; and an interactive exergame is a form of graded rehabilitation. Each has a different therapeutic target, level of patient effort, professional requirement, risk profile, expected time course, and appropriate outcome. The common element is the immersive delivery medium, not a common clinical mechanism.

This distinction matters for PICS research. If VR is treated as a uniform treatment, promising immediate changes in comfort or anxiety may be overinterpreted as evidence that it prevents a complex post-ICU syndrome. Conversely, a neutral trial of one content type may be taken to discredit other applications that operate through different pathways. A more useful question is therefore not simply whether VR "works," but how a particular VR configuration might influence a particular recovery process in a particular patient and clinical phase.

This article develops a theory-informed narrative account of

immersive VR in adult critical care recovery. It has four aims: to position VR within the multidomain concept of PICS; to describe plausible sensory, psychological, cognitive, and motor mechanisms; to interpret the existing clinical literature without assigning it a level of certainty that it cannot support; and to propose a practical framework linking intervention design, patient selection, implementation, and recovery-oriented outcomes.

2. Literature Basis and Scope

This article is a theory-informed narrative review rather than a systematic, scoping, or effectiveness review. Foundational publications on PICS, ICU liberation, and recovery were combined with peer-reviewed empirical reports of immersive head-mounted VR used with adults during ICU admission or after critical illness. Relevant reports were identified iteratively through PubMed, Europe PMC, OpenAlex, and reference checking, with the literature base updated through July 2026. Publications were used when they contributed to understanding intervention mechanisms, clinical targets, feasibility, safety, nursing delivery, or recovery outcomes.

The purpose was conceptual integration, not exhaustive identification. Accordingly, no protocol was registered; no PRISMA flow diagram or numerical screening process is reported; and no formal study-level data extraction, risk-of-bias assessment, or meta-analysis was performed. Study findings are discussed as illustrative clinical evidence and are interpreted in relation to design limitations. This approach cannot determine pooled effectiveness or guarantee that every relevant report was included. It is appropriate, however, for clarifying why apparently similar VR applications should not be treated as interchangeable and for developing a framework that can guide modest future research and clinical discussion.

3. PICS as a Multidomain Recovery Problem

3.1 The Physical Domain

Physical PICS includes weakness, loss of endurance, impaired mobility, limitations in activities of daily living, and reduced participation. These outcomes can reflect muscle catabolism, bed rest, neuromuscular dysfunction, pain, cardiorespiratory limitation, and pre-existing frailty. Recovery is rarely a simple return of strength. Patients may also fear movement, lack confidence, struggle to perceive progress, or disengage from repetitive exercise. A technology intended to support physical recovery must therefore do more than display an attractive environment. It should create an achievable task, provide meaningful feedback, permit progression, and transfer to activity outside the virtual setting.

The physical domain also illustrates the danger of confusing engagement with efficacy. A patient may enjoy an exergame and complete more repetitions during a session, yet still show no improvement in independence or mobility. Engagement is a plausible proximal outcome; actual movement dose is an intermediate process measure; functional status and participation are later outcomes. These outcomes are related but not equivalent. A theoretically coherent evaluation should measure them in that order and allow enough time for the proposed pathway to occur.

3.2 The Cognitive and Sleep-related Domain

Cognitive problems after critical illness may involve attention, memory, executive function, and processing speed. Delirium during ICU care is a distinct acute syndrome, although it is associated with later cognitive vulnerability. Sleep disruption, medications, inflammation, immobility, sensory disturbance, and loss of day-night cues may further compromise cognition. A small non-randomized study showed that selected critically ill adults could engage with a brief immersive cognitive stimulation task, but it did not establish durable cognitive recovery [7]. Immersive VR could support orientation or brief cognitive engagement, but it can also increase perceptual load. This dual possibility makes patient selection and timing essential.

For an alert but understimulated patient, a short, simple virtual task may restore interest and a sense of agency. For a fatigued patient with fluctuating attention, complex interaction may be frustrating. For a patient with active delirium, replacing the real environment may worsen disorientation or make communication more difficult. VR should therefore not be described as inherently cognitively restorative. Its cognitive effect depends on the demands of the content, the patient's current capacity, and whether the goal is orientation, stimulation, sleep preparation, or longer-term rehabilitation.

Sleep is sometimes grouped with cognitive outcomes because disrupted sleep and circadian rhythm can affect attention and delirium risk. A randomized trial of a single bedtime VR meditation session reported improvement in subjective and selected activity-derived sleep measures [8]. A calming virtual scene before the sleep period could reduce arousal or mask environmental stimulation, but a bright, novel, or interactive experience could produce the opposite effect. Subjective sleep quality, objective sleep parameters, next-day alertness, and delirium are separate outcomes. Improvement in one should not be used as evidence for all.

3.3 The Psychological Domain

Psychological recovery after intensive care is shaped by fear, pain, helplessness, fragmented or delusional memories, uncertainty, and the meaning the person assigns to the illness. Anxiety during an ICU stay may be situational and transient, but it may also interact with later avoidance, intrusive memories, or post-traumatic stress symptoms. Feasibility studies using relaxation-oriented VR reported short-term reductions in anxiety among selected ICU patients, while longer-term recovery was not established [9,10]. VR can potentially influence these processes through several routes: it can temporarily redirect attention away from the bedside; create a sense of calm or escape; explain unfamiliar ICU experiences; provide a controlled setting for emotional processing; or deliver elements of cognitive-behavioural or exposure therapy.

These routes differ in intensity. Distraction and relaxation seek to reduce immediate distress; a nurse-led quality-improvement project, for example, evaluated VR specifically as an adjunctive comfort measure [11].

Psychoeducation and memory reconstruction seek to improve understanding. Exposure therapy intentionally activates difficult memories or cues within a controlled therapeutic relationship. The last approach should not be reduced to "showing an ICU video." It requires assessment, consent, pacing, monitoring, and professional competence. The same immersive property that makes VR engaging can make poorly chosen content emotionally powerful.

3.4 Interdependence without Assuming a Single Pathway

PICS domains interact. Anxiety may reduce willingness to mobilize; poor sleep may worsen attention and emotional regulation; weakness may increase dependence and loss of confidence; cognitive impairment may make rehabilitation instructions difficult to follow. Yet interaction does not mean that every intervention should target every domain. A short relaxation session may indirectly facilitate sleep or physiotherapy, but those downstream effects require evidence. The most defensible approach is to define one primary pathway and treat cross-domain benefits as hypotheses rather than assumptions.

The multidomain nature of PICS also suggests that "recovery phase" should not be defined solely by location. Two patients in the same ICU may have very different levels of alertness, strength, distress, and cognitive capacity. ICU-specific explanatory VR has been delivered during early inpatient recovery and after COVID-19 critical illness, illustrating how timing changes the purpose of the intervention [12,13]. A survivor months after discharge may need trauma-focused therapy rather than the calming content used during acute care. Clinical phase should therefore be described using both time and function: acute stabilization, awake ICU care, early inpatient recovery, or community recovery, together with the patient's current capacities and symptoms.

4. Immersive VR as a Configurable Therapeutic Medium

The term "virtual reality" refers to a family of technologies. In this review, immersive VR means visual content delivered through a head-mounted display that substantially occludes the external visual field. Within that definition, therapeutic experience varies according to content, degree of interaction, visual motion, audio, session length, repetition, user control, posture, device weight, tracking method, and staff involvement. These design choices are not technical details added after the intervention has been defined; they are part of the intervention itself.

Clinical reports published since 2019 illustrate a wide range of therapeutic purposes. Brief cognitive stimulation and sleep preparation represent low-intensity applications [7,8]. Relaxation-oriented feasibility studies primarily target immediate anxiety, comfort, or patient experience [9,10]. ICU-specific explanation, structured psychological therapy, and active rehabilitation operate through different clinical pathways and should not be read as a single cumulative trial of "VR for PICS." A mechanism-based interpretation therefore separates three broad pathways.

4.1 Dose, Timing, and Clinical Fit

In medication research, dose is usually expressed as an amount administered over time. VR dose is multidimensional. It includes the minutes for which the headset is worn, the intensity and motion of the content, the degree of cognitive or physical effort, the number and spacing of sessions, and the amount of guidance provided by a clinician. Published ICU applications range from approximately five-minute stationary outdoor scenes to fifteen-minute guided virtual environments [14,15]. Ten minutes of passive viewing cannot be assumed equivalent to ten minutes of interactive reaching or trauma-focused exposure. Reporting only scheduled session duration hides the therapeutic exposure that the patient actually received.

A useful distinction can be made between planned dose, delivered dose, and active dose. Planned dose is what the protocol offers. Delivered dose is the time the patient actually experiences the program after delays, interruption, early stopping, or discharge. Active dose is the portion in which the intended process occurs—for example, time spent completing movements rather than navigating a menu. These differences matter in ICU care, where procedures, fatigue, clinical deterioration, and transfers frequently interrupt a schedule. A theoretically sound intervention should define the dose most relevant to its mechanism.

Timing also changes the meaning of immersion. During acute ICU care, the immediate goals are likely to be comfort, environmental modulation, orientation, or gentle engagement. The patient may have limited attention and endurance, and sessions should be brief and easily stopped. Perioperative VR-hypnosis research also shows that delivering sessions before and after surgery does not necessarily produce a between-group clinical advantage [16]. In early inpatient recovery, greater interaction may be possible, and content can support education or graded activity. After discharge, persistent symptoms can be assessed more clearly, but the intervention may need to address established anxiety, trauma, avoidance, or functional limitation rather than transient bedside distress.

Clinical fit refers to the agreement among the therapeutic target, patient capacity, content, and care setting. A highly interactive game may be technically sophisticated but poorly fitted to a weak patient who cannot hold a controller. A visually calm scene may be well fitted to immediate anxiety but poorly fitted to a survivor seeking an explanation of fragmented memories. A single ICU-specific session after COVID-19 critical illness improved satisfaction with aftercare but not psychological distress or health-related quality of life, illustrating the need to match content and outcome [13]. A realistic ICU environment may be meaningful in therapist-guided work but unnecessarily provocative when offered as generic relaxation. Fit, rather than technological novelty, is therefore the central design principle.

Personalization should operate within clinical boundaries. In one mixed-methods ICU study, patients selected travel, nature, or synthetic commercial scenes, demonstrating the practical value of offering bounded choice [17]. Adjusting difficulty can prevent frustration during rehabilitation, and language and audio can be matched to the user. However, unrestricted

access to commercial content introduces unpredictable motion, advertising, privacy concerns, and emotionally charged material. Personalization is best understood as guided choice within a curated library, with documentation of the content actually delivered.

4.2 Sensory Modulation and Attentional Capture

The first pathway begins with the ICU environment. Monitors, alarms, conversations, light, procedures, and the inability to leave the bed can create sensory overload and a sense of confinement. A head-mounted display temporarily restricts access to some of these stimuli and replaces them with a selected scene. An exploratory ICU study found high comfort and reduced real-world awareness during repeated nature-video exposure, although some sessions were not completed [18]. Calm nature content, slow visual movement, and congruent audio may therefore capture attention while reducing exposure to distressing environmental cues. The immediate target is not PICS as a whole but arousal, anxiety, discomfort, or perceived environmental burden.

Prospective ICU studies using nature or fantasy scenes reported that short sessions were generally acceptable and were followed by lower immediate anxiety in selected patients [19]. A brief mixed-methods study using nature and meditation content likewise reported improved symptom ratings with stable physiology, although the uncontrolled design limits causal inference [20]. These findings are clinically plausible because the outcomes were close to the proposed mechanism and measured soon after exposure.

However, attentional capture is time limited. Once the headset is removed, the environment and illness remain. Novelty may contribute to early response, and repeated use may become less engaging. A decrease in an anxiety score immediately after a session does not establish durable psychological recovery. Passive VR may still be worthwhile as a comfort intervention, just as music or guided imagery may be worthwhile, but its benefit should be stated at the level supported by the mechanism and measurement.

Sensory shielding also has trade-offs. Occluding the real environment can reduce awareness of staff, equipment, and family. Visual motion that is not matched to body movement can produce nausea, dizziness, eye strain, or disorientation. In a crossover relaxation trial, reported incidents included claustrophobia, agitation, and headset displacement during dyspnoea [15]. Headsets can also feel heavy, particularly in weak patients or those with facial devices. Low-motion scenes, short initial exposure, a clear stop signal, continuous communication, and display mirroring for staff are therefore not optional conveniences; they are components of safe delivery.

4.3 Presence, Explanation, and Memory Processing

The second pathway uses the sense of presence created by immersion to support understanding and psychological processing. Critical illness memories are often incomplete. Patients may remember frightening sensations or dream-like events without understanding the equipment, sedation, or sequence of care. ICU-specific VR can show a recognizable care environment, explain common devices, or help a survivor reconstruct what occurred. Its immediate target is meaning rather than escape.

ICU-specific explanatory VR has been evaluated during early recovery and after COVID-19 critical illness [12,13]. The earlier feasibility trial reported signals of lower post-traumatic stress and depression, whereas the later COVID-19 trial found improved satisfaction but no reduction in psychological distress. Timing, baseline distress, the content of the explanation, and whether a clinician helps the patient integrate the experience are therefore likely to influence effect.

Presence can also be used more intensively. A randomized clinical trial used a seven-day VR-based cognitive-behavioural program for anxiety after acute myocardial infarction and reported a modest sustained difference in clinician-rated anxiety [21]. This structured program should be distinguished from generic calming content.

Case reports have described compressed VR exposure therapy for trauma symptoms after critical illness [22,23]. Exposure is not intended to distract the patient from anxiety; it is intended to activate and modify a fear response within a therapeutic plan. This requires trained oversight, attention to readiness, and follow-up. Two individual cases do not justify routine trauma-focused VR in ICU follow-up, but they identify a pathway that deserves specialist-led investigation.

The conceptual advantage of ICU-specific VR is also its main risk. Realistic scenes may normalize equipment and fill memory gaps, but they may trigger fear or confirm distressing interpretations. Content should therefore be reviewed clinically, introduced with a clear explanation, and stopped if distress exceeds the intended therapeutic window. Patient choice and debriefing are particularly important. The person should know why the scene is being shown and what support is available afterward.

4.4 Embodiment, Feedback, and Graded Activity

The third pathway uses interactive VR to support movement and rehabilitation. Contemporary headsets can track head, hand, controller, or upper-body movement and transform it into visible action in the virtual environment. A reaching task can become catching objects, playing music, or completing a goal. This provides immediate feedback, creates a sense of agency, and may make repeated activity more meaningful.

Feasibility studies of active VR rehabilitation in patients with prolonged critical illness have shown that seated or bedside upper-limb tasks can be delivered to selected patients [24,25]. A patient-centred exergame study further showed progressively larger and faster upper-body movements within a supervised session, but it did not include a controlled functional outcome [26].

Qualitative work after cardiac surgery suggests that patients can find commercial games motivating, while repetition, inappropriate difficulty, or unfamiliar controls can reduce engagement [27]. Together, these reports support the feasibility of embodied interaction; they do not establish that

VR produces better functional recovery than conventional therapist-led exercise.

A rehabilitation mechanism requires more than headset time. Relevant dose includes active minutes, movement range, repetitions, task difficulty, rest, and progression. The system should respond to limited strength and allow the therapist to adjust demands. If the virtual goal encourages compensatory trunk movement or unsafe neck rotation, engagement may undermine rehabilitation quality. The therapist must be able to observe both the physical movement and the virtual task.

The most meaningful comparison is also not VR versus nothing. A controlled study should distinguish the effect of immersion and task feedback from the effects of therapist attention and exercise itself. An attention- and dose-matched conventional activity may be more informative than usual care. Proximal outcomes could include completion, active time, perceived exertion, enjoyment, and movement quality. Intermediate outcomes could include strength and mobility milestones. Longer-term outcomes should address activities of daily living, participation, and quality of life.

5. Interpreting the Clinical Evidence by PICS Domain

5.1 Psychological Comfort and Recovery

Psychological outcomes are frequently studied because anxiety and discomfort can change within a brief session. Two feasibility studies reported short-term reductions in anxiety among selected ICU patients [9,10]. A nurse-led comfort project and a pilot in mechanically ventilated patients reported similar immediate improvements, but neither established durable benefit [11,14].

Other prospective and mixed-methods studies also described improved immediate anxiety, mood, or patient experience after brief VR exposure [17,19]. A short pre-post study reported broad symptom improvement, whereas intervention-adaptation work emphasized acceptability, familiar content, and staff control [20,28].

Randomized and crossover evidence is more cautious. One crossover trial found improvements in discomfort and anxiety for selected electronic relaxation conditions [15]. In contrast, a four-arm perioperative trial found no significant between-group advantage for VR or VR-hypnosis [16]. The strongest defensible claim is therefore short-term comfort in selected patients, not prevention of long-term psychological PICS.

Targeted psychological content has a different evidentiary logic. ICU-specific education is intended to improve understanding of critical illness, but controlled findings have differed by population and timing [12,13]. VR-based cognitive-behavioural therapy targets anxiety through repeated structured sessions rather than momentary distraction [21]. Compressed exposure therapy addresses established trauma symptoms and has so far been reported only in individual cases [22,23]. These approaches require clarity about whether the intervention is preventive, supportive, or therapeutic.

5.2 Cognition, Delirium, and Sleep

Early VR work showed that critically ill adults could perform a brief immersive cognitive stimulation task, although performance and tolerability varied [7]. More recent multicomponent work has combined orientation, cognitive activity, exercise, and sleep-related elements in a pilot program for postoperative delirium prevention [29]. Such programs are clinically interesting but theoretically difficult to interpret because several mechanisms operate at once. A favorable signal cannot reveal which component was responsible.

Meditation and relaxation studies have examined sleep and delirium-related outcomes [8,30]. Subjective sleep improvement may reflect reduced arousal or a more positive bedtime routine, whereas objective sleep and delirium outcomes may remain unchanged. These are not contradictory findings; they sit at different points along the proposed pathway. A future trial should identify whether VR is intended to improve perceived rest, physiological sleep, circadian regularity, or delirium risk and choose measures accordingly.

Cognitive and delirium applications also require the most conservative safety boundary. Active delirium, severe agitation, inability to communicate discomfort, or unstable consciousness generally weakens the rationale for immersion. Research may eventually identify carefully designed orientation tools for patients at risk, but current evidence does not support routine use in actively delirious patients. The clinician must retain access to the patient, monitor response, and be able to remove the headset immediately.

5.3 Physical Rehabilitation

Active rehabilitation studies are promising primarily because they show that interactive VR can be integrated into early recovery without external motion-capture laboratories [24,25]. Patients can perform tasks while seated or at the bedside, and the virtual environment may make effort visible and purposeful. A supervised exergame study also demonstrated within-session movement progression, but not comparative functional efficacy [26]. Yet feasibility samples tend to include patients who are awake, cooperative, and able to use the device, which limits generalizability to those with greater medical complexity.

The next question is whether VR adds enough value to justify its burden. It may increase active time, enjoyment, or willingness to repeat movement. It may also consume staff time for setup and troubleshooting or constrain observation of posture and lines. A clinically meaningful trial would therefore combine functional outcomes with implementation measures: actual active dose, therapist time, cancelled sessions, technical failures, adverse symptoms, and whether gains transfer beyond the virtual task.

6. A Theory-Informed Pathway for VR in PICS Recovery

Figure 1 summarizes the proposed framework. It begins with ICU and recovery stressors and with patient- and

phase-specific modifiers. These conditions inform how the VR intervention is configured: content, immersion, interaction, dose, timing, and clinical support. The configuration then acts through three broad mechanisms—sensory modulation, meaning and presence, and embodied engagement—which map most directly onto psychological, cognitive/sleep, and physical targets. Nursing and therapist-enabled implementation connects these proposed mechanisms to recovery-oriented outcomes.

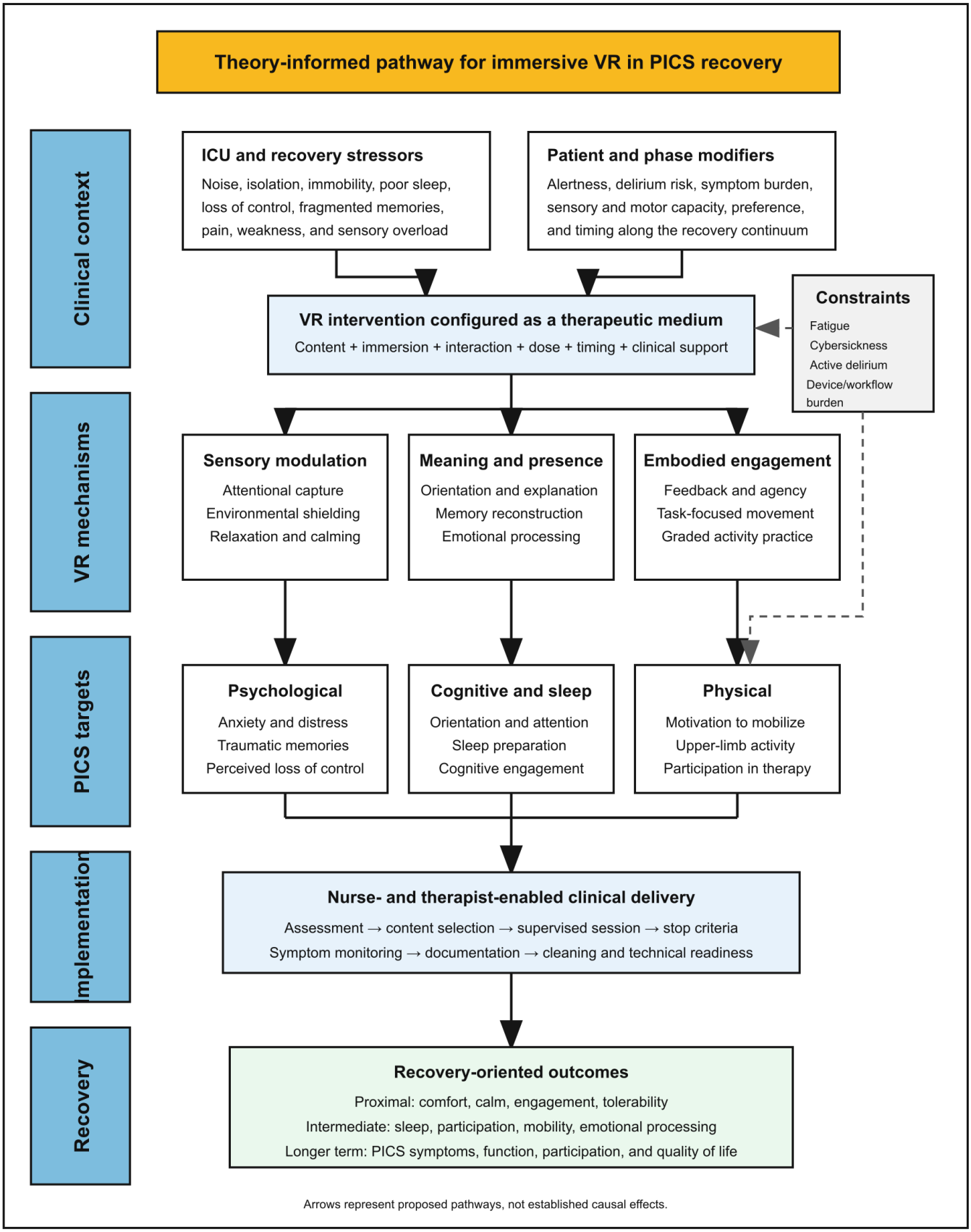

Figure 1: Theory-informed pathway for immersive VR in PICS recovery

The arrows represent proposed pathways rather than established causal effects. The model treats VR as a configurable therapeutic medium. Patient condition, recovery phase, content, dose, and clinical delivery determine whether immersion is likely to support comfort, cognitive or psychological processing, or active rehabilitation. Constraints such as fatigue, cybersickness, active delirium, and workflow burden may interrupt any pathway.

The framework is intentionally directional but not deterministic. A relaxation scene may affect psychological comfort most directly and sleep only indirectly. An exergame may improve engagement without changing mobility. ICU-specific education may help one survivor integrate memories while distressing another. The model therefore discourages broad claims and encourages a chain of aligned questions: What problem is being targeted? Which VR feature is expected to influence it? What proximal response should occur first? What clinical outcome could reasonably follow, and over what time?

This sequence also clarifies outcome selection. If the intervention is designed for sensory modulation, immediate anxiety, comfort, or tolerability is an appropriate primary outcome. If it is intended to improve sleep, exposure should occur at an appropriate time and sleep must be measured. If it is intended to increase rehabilitation dose, active movement and functional transfer are necessary. Persistent PICS outcomes should be claimed only when patients are followed beyond acute care with validated physical, cognitive, or psychological measures.

7. Clinical and Nursing Implementation

The headset is only one component of clinical VR. Before a session, staff must identify the therapeutic target and determine whether the patient can participate safely. Assessment should include alertness, ability to understand the procedure and signal distress, current delirium or agitation, nausea or vertigo, visual and hearing needs, facial or scalp vulnerability, neck comfort, oxygen interfaces, and the risk that movement could disturb tubes or lines. Clinical instability and urgent care take priority over the intervention.

Content should then be matched to the target. Low-motion, seated nature scenes may suit brief comfort or sleep preparation. ICU-specific explanation should be used only when the patient wants information and has support to discuss it. Interactive rehabilitation should be graded to motor capacity and supervised by someone who can assess movement quality. Trauma-related content requires specialist involvement. A larger content library is not automatically better; each item should be clinically reviewed for motion, height, speed, audio, language, interaction, and potentially distressing cues.

Family involvement may be helpful when it is consistent with the patient's wishes. A familiar person can explain preferences, select meaningful but safe scenes, and help the patient reconnect the virtual experience with real recovery goals. Family members should not, however, be made responsible for clinical monitoring or device safety. They also need guidance that VR is an adjunct rather than a substitute for communication, orientation, mobility, or human presence. In post-ICU settings, shared discussion after an explanatory program may be more valuable than leaving the survivor alone to interpret emotionally charged material. The appropriate family role is therefore supportive and relational, with clinical responsibility retained by trained staff.

During immersion, the patient should have a simple stop signal and should not be left without clinical observation. Display mirroring has been incorporated into nurse-supported meditation and patient-centred exergame systems, allowing staff to see what the patient sees [26,30]. The patient should be positioned safely, audio should not prevent communication, and session length should be conservative at first. Symptoms such as nausea, dizziness, headache, eye strain, panic, fatigue, or disorientation should lead to pause or termination.

Afterward, staff should document planned and actual exposure, the content used, interruptions, patient response, adverse symptoms, and technical problems. Published protocols have used combinations of disposable covers, disinfectant wipes, assigned interfaces, and ultraviolet disinfection, but procedures vary by device [9,29]. Facial interfaces, straps, controllers, headphones, and shared tablets may all require attention. Charging, software updates, secure storage, and network access also affect readiness for the next patient.

These tasks create workload that is easy to hide in a research study staffed by investigators. Rehabilitation research has documented connectivity delays and headset-related practical problems [24]. Nurse-supervised exergame delivery likewise required trained staff and an external display [26]. Implementation studies should therefore report staff minutes, professional role, training, failed attempts, cancelled sessions, technical support, device downtime, and consumable use. Without these data, a feasible research protocol may not be a feasible nursing service.

Implementation should also protect equity. Headsets may not fit all facial structures or accommodate glasses, head coverings, wounds, or respiratory equipment. Language, cultural familiarity, prior gaming experience, and digital confidence influence the experience. Qualitative work with commercial games identified learning burden, fatigue, and personalization needs [27]. Patient-and-nurse adaptation work similarly emphasized short, familiar content and staff visibility [28]. Adaptation should be considered where safe, and reasons for declining or stopping VR should be reported.

8. Boundaries of Current Knowledge

The present literature supports modest conclusions. Immersive VR can be delivered to selected, awake adults during critical care, including some mechanically ventilated patients who can communicate [14,17]. Short passive sessions are often acceptable, although non-completion and overstimulation occur [18,28].

ICU-specific educational content has been feasible during early recovery, but psychological outcomes have varied [12,13]. Structured psychological programs require repeated sessions or specialist delivery [21,22]. Interactive

rehabilitation is also feasible in selected patients, but comparative functional efficacy remains unestablished [24,25].

Serious intervention-attributed adverse events have not been prominent in these small reports. Nevertheless, claustrophobia and agitation have occurred during relaxation trials [15], and fatigue or headset burden has interrupted sensory and rehabilitation sessions [18,24]. Cybersickness has also been reported during a structured psychological intervention [21].

The literature does not establish that immersive VR prevents or treats PICS. Controlled studies have produced neutral or mixed findings for psychological distress and broader recovery outcomes [13,16]. Several positive reports are small feasibility studies, pre-post designs, or individual trauma cases [20,23]. Participants are commonly selected for alertness and ability to use the equipment, which limits applicability to patients with delirium, severe weakness, sensory impairment, or greater instability. Immediate patient-reported outcomes remain more common than longitudinal physical, cognitive, or psychological recovery measures.

This narrative review has corresponding limitations. Literature was selected purposefully for conceptual relevance and was not identified through a systematic review process. No formal study selection log, data extraction, or risk-of-bias assessment was undertaken. The discussion may therefore omit relevant studies and cannot provide an unbiased estimate of effect. The proposed framework is an interpretive model derived from PICS concepts, clinical practice principles, and the available VR literature; it has not itself been validated. These limitations are deliberate and should remain visible in any submitted version.

9. Priorities for Modest Future Research

Future research does not need to begin with a large definitive trial. A small, well-defined study can be useful if it tests one mechanism and reports its limits honestly. For example, a pilot of low-motion relaxation VR could focus on tolerability, completion, immediate anxiety, and nursing workload in awake ICU patients. A rehabilitation pilot could focus on active minutes, movement quality, progression, and transfer to a simple functional measure. An ICU education study could assess comprehension, emotional response, and acceptability before planning longer psychological follow-up.

Three principles would strengthen such work. First, the therapeutic claim should be narrow. “VR reduces immediate anxiety during an awake ICU session” is testable; “VR improves PICS” is too broad for a small pilot. Second, the comparator and outcome should correspond to the mechanism. Relaxation VR might be compared with guided audio or tablet video; rehabilitation VR with dose-matched conventional activity. Third, implementation should be treated as an outcome rather than background. Staff time, interruptions, technical problems, cleaning, and reasons for non-completion determine whether an intervention can move beyond a demonstration.

Longer-term studies should be considered only after feasibility and mechanism are credible. They should enroll patients with a defined risk or symptom profile, prespecify one primary PICS domain, and measure outcomes at a time when change is plausible. Blinded outcome assessment may be possible even when participants cannot be blinded. Reports should distinguish planned exposure from actual headset and active task time. Patient and family input should guide content and acceptable burden.

The most productive research program may therefore be modular. A common clinical platform can support different modules for comfort, orientation, psychological therapy, and activity, but each module should retain its own rationale, eligibility criteria, safety procedures, dose, professional role, and outcome. This preserves the flexibility of VR without collapsing all applications into an uninformative category.

10. Conclusion

Immersive VR is a promising but heterogeneous medium for supporting recovery from critical illness. Its most plausible roles include brief sensory modulation, ICU-specific explanation and psychological processing, and feedback-rich graded activity. These roles map onto different PICS domains and should not be evaluated or implemented as though they were one treatment. Current evidence supports feasibility and possible short-term benefit in selected patients, not a claim that VR prevents or treats PICS. Clinical value will depend on a precise therapeutic target, appropriate content and dose, careful patient selection, trained supervision, and outcomes that follow the proposed mechanism. Until these conditions are tested more rigorously, immersive VR should be regarded as a configurable adjunct to recovery-oriented care rather than a standard PICS intervention.

Funding:

This work was supported by the Zhengzhou Sias University Scientific Research Project (Project No. 2025XKD094).

References

[1] Needham DM, Davidson J, Cohen H, Hopkins RO, Weinert C, Wunsch H, et al. Improving long-term outcomes after discharge from intensive care unit: report from a stakeholders' conference. Crit Care Med. 2012; 40(2):502-509. doi:10.1097/CCM.0b013e318232da75.

[2] Inoue S, Hatakeyama J, Kondo Y, Hifumi T, Sakuramoto H, Kawasaki T, et al. Post-intensive care syndrome: its pathophysiology, prevention, and future directions. Acute Med Surg. 2019;6(3):233-246. doi:10.1002/ams2.415.

[3] Harvey MA, Davidson JE. Postintensive Care Syndrome: Right Care, Right Now...and Later. Crit Care Med. 2016; 44(2): 381-385. doi:10.1097/CCM.0000000000001531.

[4] Marra A, Pandharipande PP, Girard TD, Patel MB, Hughes CG, Jackson JC, et al. Co-occurrence of post-intensive care syndrome problems among 406 survivors of critical illness. Crit Care Med. 2018; 46(9): 1393-1401. doi:10.1097/CCM.0000000000003218.

[5] Devlin JW, Skrobik Y, Gélinas C, Needham DM, Slooter AJC, Pandharipande PP, et al. Clinical practice

guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. Crit Care Med. 2018;46(9):e825-e873. doi:10.1097/CCM.0000000000003299.

[6] Pun BT, Balas MC, Barnes-Daly MA, Thompson JL, Aldrich JM, Barr J, et al. Caring for critically ill patients with the ABCDEF bundle: results of the ICU Liberation Collaborative in over 15,000 adults. Crit Care Med. 2019;47(1):3-14. doi:10.1097/CCM.0000000000003482.

[7] Gerber SM, Jeitziner MM, Knobel SEJ, Mosimann UP, Müri RM, Jakob SM, et al. Perception and performance on a virtual reality cognitive stimulation for use in the intensive care unit: a non-randomized trial in critically ill patients. Front Med (Lausanne). 2019;6:287. doi:10.3389/fmed.2019.00287.

[8] Lee SY, Kang J. Effect of virtual reality meditation on sleep quality of intensive care unit patients: a randomised controlled trial. Intensive Crit Care Nurs. 2020; 59:102849. doi:10.1016/j.iccn.2020.102849.

[9] Ong TL, Ruppert MM, Akbar M, Rashidi P, Ozrazgat-Baslanti T, Bihorac A, et al. Improving the intensive care patient experience with virtual reality: a feasibility study. Crit Care Explor. 2020;2(6):e0122. doi:10.1097/CCE.0000000000000122.

[10] Jawed YT, Golovyan D, Lopez D, Khan SH, Wang S, Freund C, et al. Feasibility of a virtual reality intervention in the intensive care unit. Heart Lung. 2021; 50(6):748-753. doi:10.1016/j.hrtlng.2021.05.007.

[11] Kissel KA, Soo A, Tateson Bennett K. Virtual reality as an adjunctive comfort measure in the intensive care and coronary care unit: a nurse-led quality improvement project. Can J Crit Care Nurs. 2021;32(4):5-13. doi:10.5737/23688653-324513.

[12] Vlake JH, Van Bommel J, Wils EJ, Korevaar TIM, Bienvenu OJ, Klijn E, et al. Virtual reality to improve sequelae of the postintensive care syndrome: a multicenter, randomized controlled feasibility study. Crit Care Explor. 2021;3(9):e0538. doi:10.1097/CCE.0000000000000538.

[13] Vlake JH, van Bommel J, Wils EJ, Bienvenu J, Hellemons ME, Korevaar TI, et al. Intensive care unit-specific virtual reality for critically ill patients with COVID-19: multicenter randomized controlled trial. J Med Internet Res. 2022; 24(1): e32368. doi:10.2196/32368.

[14] Haley AC, Wacker DA. Cinematic virtual reality for anxiety management in mechanically ventilated patients: a feasibility and pilot study. Acute Crit Care. 2022; 37(2): 230-236. doi:10.4266/acc.2021.00843.

[15] Merliot-Gailhoustet L, Raimbert C, Garnier O, Carr J, De Jong A, Molinari N, et al. Discomfort improvement for critically ill patients using electronic relaxation devices: results of the cross-over randomized controlled trial E-CHOISIR. Crit Care. 2022; 26(1): 263. doi:10.1186/s13054-022-04136-4.

[16] Rousseaux F, Dardenne N, Massion PB, Ledoux D, Bicego A, Donneau AF, et al. Virtual reality and hypnosis for anxiety and pain management in intensive care units: a prospective randomised trial among cardiac surgery patients. Eur J Anaesthesiol. 2022;39(1):58-66. doi:10.1097/EJA.0000000000001633.

[17] Locke BW, Tsai TY, Reategui-Rivera CM, Gabriel AS, Smiley A, Finkelstein J. Immersive virtual reality use in medical intensive care: mixed methods feasibility study. JMIR Serious Games. 2024; 12: e62842. doi:10.2196/62842.

[18] Naef AC, Gerber SM, Single M, Müri RM, Haenggi M, Jakob SM, et al. Effects of immersive virtual reality on sensory overload in a random sample of critically ill patients. Front Med (Lausanne). 2023; 10: 1268659. doi:10.3389/fmed.2023.1268659.

[19] Martí-Hereu L, Navarra-Ventura G, Navas-Pérez AM, Férnandez-Gonzalo S, Pérez-López F, de Haro-López C, et al. Usage of immersive virtual reality as a relaxation method in an intensive care unit. Enferm Intensiva (Engl Ed). 2024; 35(2): 107-113. doi:10.1016/j.enfie.2023.08.005.

[20] Ju X, Jiang L, Yang J, Zheng Q, Liu X. Enhancing patient experience in the surgical ICU through virtual reality: a pre-post mixed-methods study. Heart Lung. 2025;70:93-101. doi:10.1016/j.hrtlng.2024.11.014.

[21] Li YY, Peng J, Ping YY, Jia Jun W, Lu Y, Liu JJ, et al. Virtual reality-based cognitive-behavioural therapy for the treatment of anxiety in patients with acute myocardial infarction: a randomised clinical trial. Gen Psychiatr. 2024; 37(2): e101434. doi:10.1136/gpsych-2023-101434.

[22] Peach BC, Cox CL. Using compressed virtual reality exposure therapy for an adult critical illness survivor: a case report. Crit Care Nurse. 2024;44(6):35-40. doi:10.4037/ccn2024513.

[23] Peach BC, Davis JW, Cox C, Beidel DC. Compressed virtual reality exposure therapy used to habituate a critical illness survivor's psychological trauma symptoms: a case report. Dimens Crit Care Nurs. 2025; 44(5): 256-261. doi:10.1097/DCC.0000000000000711.

[24] Haghedooren E, Haghedooren R, Langer D, Gosselink R. Feasibility and safety of interactive virtual reality upper limb rehabilitation in patients with prolonged critical illness. Aust Crit Care. 2024;37(6):949-956. doi:10.1016/j.aucc.2024.06.004.

[25] de Vries M, Beumeler LFE, van der Meulen J, Bethlehem C, den Otter R, Boerma EC. The feasibility of virtual reality therapy for upper extremity mobilization during and after intensive care unit admission. PeerJ. 2025; 13: e18461. doi:10.7717/peerj.18461.

[26] Eom S, Hu T, Xu W, Zou L, Escobar E, Streisfeld G, et al. Rhythms of recovery: patient-centered virtual reality exergame for physical rehabilitation in the intensive care unit. IEEE Trans Vis Comput Graph. 2026; 32(5): 3679-3689. doi:10.1109/TVCG.2026.3680730.

[27] Wu Z, Li X, Li L, Zhang Y, Shen X. Perceptions and experiences of commercial virtual reality games in early postoperative rehabilitation among cardiac surgical patients: a qualitative study. Digit Health. 2025; 11: 20552076251315793. doi:10.1177/20552076251315793.

[28] Hanifa AL, Dreyer P, Aagaard S, Holm A. Virtual reality for relaxation in intensive care unit patients: feasibility, acceptability and intervention adaptation. Pilot Feasibility Stud. 2025;11(1):124. doi:10.1186/s40814-025-01707-4.

[29] Dong J, Ni Q, Gong X, Sui W, Wang L, Huang Z, et al. A virtual reality-based multicomponent intervention program for preventing postoperative delirium in the intensive care unit for cardiac surgery patients: from evidence-based design to a pilot trial. Front Med (Lausanne). 2026;13:1815659. doi:10.3389/fmed.2026.1815659.

[30] Kim S, Kang J. Effects of virtual reality meditation on sleep and delirium in ICU patients: a randomized controlled trial. Comput Inform Nurs. 2025; 43(8): e01307. doi:10.1097/CIN.0000000000001307.