

Feasibility, Usability, and Acceptability of a Nurse-Facilitated, Phase-Matched Virtual Reality Intervention After ICU Extubation: A Mixed-Methods Study

Sijing Li

Guizhou Nursing Vocational College

Zhixia Jiang

jzxh1@126.com

Guizhou Nursing Vocational College

Guanghui Xie

Guizhou Nursing Vocational College

Xiaoling Yang

Guizhou Nursing Vocational College

Shisi Dai

Guizhou Nursing Vocational College

Yuanqing Qing

Affiliated Hospital of Zunyi Medical University

Fang Chen

Affiliated Hospital of Zunyi Medical University

Jie Zou

Affiliated Hospital of Zunyi Medical University

Mingjia Zhen

Affiliated Hospital of Zunyi Medical University

Yi Yang

Guizhou Provincial People's Hospital

Research Article

Keywords: virtual reality, critical care nursing, intensive care units, psychological support, post-extubation recovery, feasibility studies

Posted Date: September 23rd, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10715974/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Objectives

To evaluate the feasibility, usability, tolerability, acceptability and exploratory psychological effects of an investigator-developed multicomponent virtual reality (VR) intervention after ICU extubation.

Methods

A preference-based, non-randomised controlled mixed-methods feasibility study was conducted in a general ICU in China. Adults who had received invasive mechanical ventilation for more than 48 h selected VR plus usual care or usual care alone. The phase-matched intervention combined ICU environmental familiarisation, treatment education, relaxation and mindfulness, and personalised videos from family members and clinicians. Feasibility, usability and tolerability were assessed through recruitment, VR uptake and completion, session delivery, staff assistance, the System Usability Scale and adverse-event monitoring. Anxiety, depressive and post-traumatic stress symptoms were assessed at baseline, ICU discharge and 1 month. Semistructured interviews explored acceptability.

Results

Of 70 eligible patients, 54 enrolled (77.1%); 31 initiated VR and 23 received usual care alone. Thirty completed the VR intervention (96.8%) and undertook 185 sessions (mean 6.17 per participant; 7.08 min per session). Twenty-four used the system with minimal assistance and six required continued staff support. The mean System Usability Scale score was 79.42 (SD 7.09). One participant discontinued during the initial session because of mild transient dizziness and nausea; no serious VR-related adverse events or technical failures occurred. One usual-care participant died before 1-month follow-up. Adjusted exploratory analyses showed lower psychological symptom scores in the VR group at ICU discharge and 1 month. Interviews indicated that acceptability depended on recovery phase, physical capacity, ease of operation and bedside support.

Conclusions

The nurse-facilitated, phase-matched VR intervention was deliverable and generally acceptable among selected postextubation ICU patients. Successful implementation required bedside assessment, flexible content selection, operational assistance, and monitoring for discomfort. Psychological findings were exploratory and should not be interpreted as evidence of effectiveness because of preference-based allocation, baseline imbalance, and the small sample.

Introduction

Survivors of critical illness frequently experience physical, cognitive and psychological problems described as post-intensive care syndrome (PICS) [1, 2]. Psychological sequelae commonly include anxiety, depressive and post-traumatic stress disorder (PTSD) [3, 4]. The early postextubation period is a particularly vulnerable phase. As patients regain awareness after invasive mechanical ventilation, they may experience physical weakness, communication difficulties, fluctuating attention, fragmented memories and uncertainty about their illness, treatment and the intensive care unit (ICU) environment [5]. These experiences can contribute to fear, disorientation and distressing illness-related memories, highlighting the need for early psychological support alongside ongoing critical care [6].

Several nonpharmacological strategies have been used to support psychological recovery after critical illness. Follow-up consultations have been evaluated for post-ICU syndrome, although the evidence remains limited and heterogeneous [7]. ICU diaries have shown potential benefits for some psychological and recovery-related outcomes, but their effects are inconsistent [8]. A randomised clinical trial involving mechanically ventilated patients found no significant reduction in PTSD at three months [9]. Follow-up services are generally delivered after ICU discharge, while diary-based interventions do not consistently provide interactive, individualised support during the immediate postextubation period. Delivery of repeated psychological support in routine ICU care is also constrained by staff workload, fluctuating patient readiness, impaired communication and variable family availability.

Virtual reality (VR) provides a structured, immersive and repeatable platform for informational and relaxation-based support. Preliminary evidence suggests that VR may help ICU patients understand their ICU experience and treatment, while meditative VR and related electronic relaxation interventions may improve patient experience or reduce discomfort in selected critically ill patients [10–14]. Evidence in critical care remains preliminary, and questions regarding tolerability, usability and bedside implementation require further evaluation. Moreover, a

fixed sequence of VR content may not accommodate the rapidly changing needs and tolerance of patients during early postextubation recovery.

The Timing-It-Right (TIR) framework supports matching psychological care to patients' changing needs across recovery phases [15, 16]. During early postextubation recovery, support may progress from reassurance and comfort to environmental reorientation, treatment explanation and preparation for continued recovery, with content adapted to patients' physical condition, cognitive capacity, emotional readiness and tolerance.

To address these gaps, we developed a phase-matched multicomponent VR intervention combining ICU environmental familiarisation, treatment education, relaxation and mindfulness, and personalised videos from family members and clinicians. Although intended to support psychological recovery, this study primarily evaluated the feasibility of the study procedures and intervention, including usability, tolerability and acceptability. Psychological outcomes were explored to inform refinement and a future randomised controlled trial.

Methods

Study design

This feasibility study used a prospective, preference-based, non-randomised controlled design. Given the individualised and phase-matched nature of the intervention, quantitative and qualitative approaches were combined. We focused on participant feedback and on the feasibility of the study procedures and intervention. The findings were intended to inform further refinement and a future randomised controlled trial. Reporting was guided by recommendations for non-randomised feasibility studies and the COREQ checklist [17].

Participants and setting

This study was conducted in the general ICU of the Affiliated Hospital of Zunyi Medical University, a tertiary hospital in Guizhou Province, China, between September 2023 and January 2024. Adults aged 18–65 years were eligible if they had received invasive mechanical ventilation for more than 48 h, had been successfully extubated, were clinically stable, could communicate and were considered able to tolerate VR. Exclusion criteria were severe visual or hearing impairment, a history of severe motion sickness or vestibular disorder, unstable cardiopulmonary status, severe cognitive impairment, or a major psychiatric disorder that could compromise informed consent, VR exposure or outcome assessment.

Recruitment

Potentially eligible patients were consecutively screened after successful extubation by trained research staff in collaboration with the treating ICU clinicians. Eligibility was assessed using the predefined inclusion and exclusion criteria. Patients meeting the criteria received standardised verbal and written information about the study procedures, the VR intervention, usual care and potential discomforts. Written informed consent was obtained before enrolment. Baseline demographic and clinical data were collected through patient interviews and medical-record review, including age, sex, education, residence, emergency ICU admission, APACHE II score, delirium during the ICU stay, duration of mechanical ventilation, ICU and general ward lengths of stay, total medical costs and baseline psychological outcome scores. Reasons for exclusion or non-participation were documented in a screening log.

After enrolment, participants selected either VR plus usual care or usual care alone. Participants who selected VR formed the intervention group, whereas those who declined VR but agreed to complete the study assessments formed the usual-care comparison group. Usual care comprised routine medical and nursing care, physiological monitoring, symptom management, clinical explanations and family communication; control participants did not receive structured VR exposure.

Intervention

The investigator-developed VR intervention was created by an interdisciplinary team and informed by the Timing-It-Right framework. It comprised four components: ICU environmental familiarisation, ICU treatment education, relaxation and mindfulness, and personalised reinforcement. The intervention was delivered with a PICO NEO3 head-mounted display (Qingdao Pico Technology Co., Ltd., Qingdao, China) and an investigator-developed software platform.

The first 72 h after extubation were operationalised as a stress phase (within 24 h), buffer phase (24–48 h) and acceptance phase (48–72 h). These periods guided content prioritisation rather than a fixed sequence. Content could be introduced, revisited or postponed according

to clinical condition, cognitive and emotional readiness, preference and tolerance (Table 1; Fig. 1).

Trained ICU nurses and nurse researchers delivered the intervention at the bedside. Before each session, they assessed alertness, clinical stability, comfort, willingness and readiness. Content was selected according to time since extubation, physical condition, emotional readiness, preference and previous response to VR. Nurses assisted with positioning, headset fitting, content selection and controller operation when required, and monitored dizziness, nausea, visual discomfort, dyspnoea, emotional distress, oxygen desaturation and arrhythmia. Sessions were scheduled around routine treatment and nursing care and were stopped at the participant's request or when discomfort or a clinical concern arose. No fixed number of sessions was prescribed; session timing and frequency were adjusted according to readiness and tolerance.

Table 1
Phase-matched content of the multicomponent VR support system

Delivery period	Intended support	Prioritised components	Intervention content
Stress phase: within 24 h	Comfort and low cognitive burden	Relaxation and mindfulness; personalised reinforcement	Calming natural environments, guided breathing or mindfulness, brief orientation and personalised reassuring videos.
Buffer phase: 24–48 h	Reorientation and treatment understanding	ICU environmental familiarisation; ICU treatment education	Nurse-guided viewing of ICU areas, equipment, tubes, alarms, procedures and staff roles, with brief treatment explanations.
Acceptance phase: 48–72 h	Understanding, reassurance and recovery confidence	ICU treatment education; personalised reinforcement	Review of treatment and recovery experiences, recovery-oriented information and videos recorded for the patient by family members and clinicians.

Nurse-facilitated intervention delivery

Outcomes and Measures

Primary outcomes were process feasibility, intervention feasibility, usability, tolerability and acceptability. Process feasibility was assessed through recruitment and completion of scheduled assessments. Intervention feasibility was assessed through VR uptake, initiation, completion, session frequency and duration, component use, staff assistance, discontinuation and technical failures. Session-use measures were calculated among intervention completers.

Usability was assessed after the final VR session using the 10-item System Usability Scale, which produces a score from 0 to 100; higher scores indicate better perceived usability [18]. Tolerability was assessed among all participants who initiated VR through prospective monitoring of symptoms and clinically relevant events. Acceptability was examined through uptake, completion and interviews.

Psychological outcomes were secondary and exploratory. Anxiety and depressive symptoms were assessed using the Chinese version of the Hospital Anxiety and Depression Scale [19], and post-traumatic stress symptoms using the Chinese version of the Impact of Event Scale–Revised [20]. Assessments occurred at baseline, ICU discharge and 1-month follow-up.

Sample size

We aimed to recruit approximately 60 participants. No formal power calculation was performed because this was a feasibility study. The target was determined pragmatically from expected recruitment and the feasibility of delivering the intervention in routine ICU care.

Qualitative data collection

After completing the intervention, a purposive sample of 12 participants from the VR group took part in semistructured interviews. Sampling sought variation in demographic and clinical characteristics, previous VR experience, system use and need for assistance. Interviews explored experiences, perceived value, barriers and suggestions for refinement. Interviews were audio-recorded with consent, transcribed verbatim and deidentified. The interview guide is provided in Supplementary File 1.

Data analysis

Data were entered into EpiData and analysed using IBM SPSS Statistics version 29.0. Continuous variables were summarised as means and standard deviations or medians and interquartile ranges, and categorical variables as frequencies and percentages. Baseline characteristics

were compared using independent-samples t tests, Mann–Whitney U tests, chi-square tests or Fisher’s exact tests, as appropriate.

Psychological outcomes at ICU discharge and 1-month follow-up were analysed using multivariable linear regression adjusted for the corresponding baseline score, age and APACHE II score. Adjusted mean differences with 95% confidence intervals and P values were reported. Tests were two-sided, with $P < 0.05$ considered nominally significant. No adjustment was made for multiple comparisons. Complete-case analyses were used and no values were imputed.

Interview transcripts were analysed using Braun and Clarke’s six-phase thematic analysis [21]. Two researchers independently read and coded the transcripts, developed and reviewed candidate themes, and resolved differences through discussion. Quantitative and qualitative findings were integrated during interpretation.

Ethics and registration

The study was approved by the Ethics Committee of the Affiliated Hospital of Zunyi Medical University (KLLY-2022-069; 30 December 2022), conducted in accordance with the Declaration of Helsinki and registered with the Chinese Clinical Trial Registry (ChiCTR2300068874; 1 March 2023). All participants provided written informed consent. Separate consent was obtained from family members and clinicians appearing in personalised videos. Interview data were deidentified before analysis.

Results

Participant Flow and Baseline Characteristics

A total of 329 ICU patients were screened during the recruitment period. Of these, 259 did not meet the eligibility criteria, leaving 70 eligible for enrolment. Sixteen eligible patients declined participation, and 54 provided written informed consent. Of these, 31 selected VR plus usual care and 23 selected usual care alone.

Among the 31 participants who initiated VR, 30 completed the intervention. One participant discontinued during the first session because of mild transient dizziness and nausea; the symptoms resolved after removal of the headset without medical treatment. One participant in the usual-care group died before the 1-month follow-up. All 54 enrolled participants contributed to the feasibility analyses, and all 31 participants who initiated VR contributed to the tolerability analysis. Complete psychological outcome data were available for 52 participants, comprising 30 in the VR group and 22 in the usual-care group. Twelve participants from the VR group participated in semistructured interviews (Fig. 2).

Among the 52 participants included in the complete-case psychological outcome analyses, those in the VR group were younger than those in the usual-care group (mean 42.5 years, SD 13.8 vs mean 55.5 years, SD 12.1; $P < 0.001$). Educational attainment and place of residence also differed between groups, with participants in the VR group having higher educational attainment and being less likely to live in rural areas. No statistically significant between-group differences were found in sex, emergency ICU admission, APACHE II score, delirium during the ICU stay, duration of mechanical ventilation, ICU or general ward length of stay, total medical costs, or baseline psychological outcome scores (Table 2).

Table 2

Baseline demographic and clinical characteristics of participants included in the complete-case psychological outcome analyses (N = 52)

Characteristic	All participants (N = 52)	Control group (n = 22)	VR group (n = 30)	P value
Age (years), mean (SD)	48.0 (14.5)	55.5 (12.1)	42.5 (13.8)	< .001
Sex, n (%)				.161
Male	30 (57.7)	10 (45.5)	20 (66.7)	
Female	22 (42.3)	12 (54.5)	10 (33.3)	
Education, n (%)				< .001
Primary school or below	20 (38.5)	15 (68.2)	5 (16.7)	
Junior high school	19 (36.5)	6 (27.3)	13 (43.3)	
High school/technical secondary school	9 (17.3)	1 (4.5)	8 (26.7)	
College/bachelor's degree or above	4 (7.7)	0 (0.0)	4 (13.3)	
Residence, n (%)				.006
Rural	9 (17.3)	8 (36.4)	1 (3.3)	
Town	25 (48.1)	7 (31.8)	18 (60.0)	
Urban	18 (34.6)	7 (31.8)	11 (36.7)	
Emergency ICU admission, n (%)				1.000
Yes	32 (61.5)	14 (63.6)	18 (60.0)	
No	20 (38.5)	8 (36.4)	12 (40.0)	
APACHE II score, median (IQR)	20.5 (13.8–25.8)	22.5 (17.2–25.0)	18.5 (12.0–27.2)	.224
Delirium during ICU stay, n (%)				.400
Yes	26 (50.0)	9 (40.9)	17 (56.7)	
No	26 (50.0)	13 (59.1)	13 (43.3)	
Mechanical ventilation duration (h), median (IQR)	107.5 (54.0–174.0)	101.5 (56.5–256.2)	107.5 (54.0–168.8)	.547
ICU length of stay (days), median (IQR)	8.0 (5.0–13.2)	8.0 (5.0–17.8)	8.5 (5.0–12.0)	.676
General ward length of stay (days), median (IQR)	7.0 (4.0–11.0)	6.5 (4.0–9.0)	8.0 (4.2–13.0)	.145
Total medical cost (CNY), median (IQR)	65202.5 (42036.2–133128.0)	67590.5 (43616.0–133728.0)	65202.5 (41602.8–130838.8)	.978
Baseline HADS-Anxiety, mean (SD)	9.7 (3.2)	9.4 (3.2)	10.0 (3.1)	.538
Baseline HADS-Depression, mean (SD)	11.0 (2.8)	11.5 (3.1)	10.7 (2.6)	.333
Baseline IES-R, mean (SD)	30.7 (9.3)	29.6 (10.1)	31.4 (8.7)	.514

APACHE II, Acute Physiology and Chronic Health Evaluation II; CNY, Chinese yuan; HADS, Hospital Anxiety and Depression Scale; ICU, intensive care unit; IES-R, Impact of Event Scale-Revised; VR, virtual reality.

Process and intervention feasibility

Of the 70 eligible patients, 54 enrolled (77.1%). Complete psychological outcome data across all three assessment points were available for 52/54 participants (96.3%). VR uptake was 57.4% (31/54). All 31 participants selecting VR initiated the intervention, and 30/31 completed it (96.8%).

The 30 completers completed 185 sessions, with a mean of 6.17 sessions per participant and a mean duration of 7.08 min. After initial instruction, 24/30 participants (80.0%) used the system with minimal assistance, whereas 6/30 (20.0%) required continued support with

headset set-up, content selection or controller operation. Detailed use data are provided in Supplementary File 2.

Usability and tolerability

Among the 30 intervention completers, the mean System Usability Scale score was 79.42 (SD 7.09; 95% CI 76.77–82.07). No serious VR-related adverse events or technical failures were recorded. One participant discontinued during the initial session because of mild transient dizziness and nausea; the symptoms resolved after headset removal without medical treatment.

Exploratory Psychological Outcomes

Psychological scores are presented in Table 3 and Fig. 3. After adjustment for baseline score, age and APACHE II score, HADS-A, HADS-D and IES-R scores were lower in the VR group at ICU discharge and 1-month follow-up (all $P < 0.001$).

Table 3
Exploratory psychological outcomes at baseline, ICU discharge, and 1-month follow-up.

Outcome	VR group baseline, mean (SD)	VR group ICU discharge, mean (SD)	VR group 1-month follow-up, mean (SD)	Control group baseline, mean (SD)	Control group ICU discharge, mean (SD)	Control group 1-month follow-up, mean (SD)	Adjusted between-group difference at ICU discharge (95% CI)	P value	Adjusted between-group difference at 1-month follow-up (95% CI)	P value
HADS-Anxiety(SD)	10.0 (3.1)	5.5 (2.3)	2.0 (1.6)	9.4 (3.2)	8.9 (3.4)	6.3 (3.5)	-4.03 (-6.18 to -1.88)	< .001	-4.62 (-6.72 to -2.52)	< .001
HADS-Depression(SD)	10.7 (2.6)	5.6 (2.8)	2.5 (2.0)	11.5 (3.1)	10.2 (4.6)	8.0 (3.8)	-4.30 (-6.69 to -1.92)	< .001	-5.16 (-7.03 to -3.30)	< .001
IES-R(SD)	31.4 (8.7)	16.5 (7.8)	5.0 (5.8)	29.6 (10.1)	28.0 (12.8)	23.5 (11.8)	-13.39 (-20.01 to -6.76)	< .001	-21.33 (-27.91 to -14.75)	< .001

Adjusted between-group differences were estimated using multivariable linear regression controlling for the corresponding baseline score, age and APACHE II score. Negative values indicate lower scores in the VR group.

T0: pre-intervention; T1: post-intervention/ICU discharge; T2: 1-month follow-up.

Qualitative Findings

Thematic analysis of 12 interviews generated three themes: perceived benefits and engagement, factors influencing use, and barriers and optimisation needs. Participants described reorientation, treatment understanding, reassurance and relaxation, but use was influenced by physical capacity, previous VR experience and psychological readiness. Controller burden, interface complexity, visual discomfort and headset weight limited independent use. Feasibility and acceptability therefore depended on phase-matched content, ease of use, physical tolerability and staff support (Fig. 4; Table 4).

Table 4
Selected qualitative findings and illustrative quotations

Theme	Subtheme	Interpretation	Illustrative quotation
Perceived benefits and engagement	Ease of use	Initial instruction helped participants learn to use the system.	H2: "I thought it would be complicated and was worried at first, but after the explanation I knew how to use it."
Perceived benefits and engagement	Reorientation	ICU information reduced uncertainty about equipment and alarms.	H7: "At first, the machine alarms frightened me. After using the system, I understood why they sounded and felt less afraid."
Factors influencing use	Emotional readiness	Some participants avoided treatment-related content when they felt vulnerable.	H3: "I was afraid the treatment-related content would be too much, so I chose my family's videos and the natural scenes to help me relax."
Factors influencing use	Physical capacity	Weakness affected controller use early after extubation.	H4: "On the first day, my hands were too weak to use the controller. Later, as I recovered, I could use it."
Barriers and optimisation needs	Controller burden	Handheld interaction was inconvenient for some participants.	H11: "Clicking through the options with the controller was troublesome."
Barriers and optimisation needs	Headset comfort	Device weight reduced comfort.	H2: "I hope the device can be lighter; it felt heavy."

Mixed-methods integration

The high completion rate and System Usability Scale score were consistent with generally favourable interview accounts. The six participants requiring continued assistance reflected reports of weakness, limited VR experience and controller difficulty. Reports of discomfort and headset burden also explained the need for bedside monitoring and flexible support. The findings support delivery as an individualised, staff-supported intervention rather than a fully self-directed programme.

Discussion

Principal findings

The intervention was deliverable to selected postextubation ICU patients. Thirty of 31 participants initiating VR completed the intervention, perceived usability was good and no serious VR-related adverse events or technical failures were recorded. Six participants required continued assistance, indicating that staff support was part of delivery rather than an optional addition. Interviews similarly showed that acceptability depended on recovery phase, physical capacity, ease of operation and bedside support. Lower psychological symptom scores were observed in the VR group, but the study does not establish effectiveness.

Comparison with prior work

Severe stress during intensive care is associated with poorer psychological and quality-of-life outcomes [22]. Non-pharmacological interventions have produced mixed findings: ICU diaries reduced post-traumatic stress symptoms in some studies [23, 24], whereas others found limited effects [25]. The present intervention differed by delivering interactive informational and emotional support during early postextubation recovery rather than relying mainly on retrospective reconstruction.

VR research in critical care remains preliminary [26]. Previous work has focused largely on relaxation or meditation [27]. Here, relaxation was combined with ICU-specific familiarisation, treatment education and personalised videos, with content selected according to recovery phase and tolerance. This approach is consistent with reports that ICU technology, noise, procedures and loss of control are important sources of distress [28, 29]. Physical discomfort and psychological symptoms are also closely related [30], while family members frequently experience distress during critical illness [31]. Personalised content may therefore complement, rather than replace, interpersonal support.

Feasibility and implementation

High completion did not mean independent use. Weakness, reduced hand function, fatigue and limited VR experience affected controller operation and content selection. Bedside staff were needed to assess readiness, assist with positioning and operation, and monitor discomfort. Participants selecting VR were younger, had higher educational attainment and were less likely to live in rural areas, suggesting that accessibility requires attention. Simplified navigation, reduced controller dependence, voice guidance and assisted-use options may broaden access.

Headset comfort, visual clarity, positioning, infection control and staff time also require evaluation. Future studies should prospectively record technical problems, adverse events, interruptions, cleaning requirements, staff workload and reasons for non-use, consistent with recommendations for digital health and VR trials [32, 33].

Exploratory psychological outcomes

Adjusted analyses showed lower HADS-A, HADS-D and IES-R scores in the VR group at ICU discharge and 1 month. The consistency across outcomes supports further evaluation, but not conclusions about effectiveness. Preference-based allocation produced differences in age, education and residence; residual confounding by digital confidence, motivation and treatment expectations remains possible. The study also examined several outcomes and time points without multiplicity adjustment.

A future randomised trial should prespecify a primary outcome and assessment point, use concealed allocation and blinded outcome assessment where feasible, and extend follow-up beyond 1 month. Functional recovery and health-related quality of life should be included because recovery after critical illness extends beyond psychological symptoms [34, 35].

Strengths and limitations

Strengths include prospective assessment of recruitment, uptake, intervention delivery, assistance, usability, tolerability and technical performance, together with a usual-care comparison group and participant interviews. Integration of the findings distinguished intervention completion from independent use.

The preference-based design introduced selection bias and baseline imbalance. Participants and staff could not be blinded, and self-reported outcomes may have been influenced by expectation or novelty. The small, single-centre sample was not powered for effectiveness, follow-up was limited to 1 month and complete-case analyses excluded two participants. The upper age limit and exclusion of patients with cognitive, communication, visual or hearing impairment restrict generalisability. Interviews included VR participants only; views of decliners, the participant who discontinued, families and staff were not formally examined. Staff workload, costs and organisational readiness were also not measured. Broader populations, longer follow-up and standardised outcomes across psychological, physical, cognitive and social recovery are needed [36–39].

Conclusions

This mixed-methods feasibility study found that the multicomponent VR intervention could be delivered to selected postextubation ICU patients with high completion and good perceived usability. Acceptability depended on clinical readiness, content relevance, operational simplicity and bedside support. Lower psychological symptom scores were observed in the VR group, but the preference-based allocation, baseline imbalances and small sample preclude conclusions about effectiveness. A randomised trial is needed after further refinement of the intervention and delivery procedures.

Declarations

Competing interests

The authors declare no competing interests.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the authors used ChatGPT (OpenAI) to assist with language editing and manuscript organisation. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Funding

This work was supported by the Health Commission of Guizhou Province(No. gzwkj2025-503), Institutional Project of Guizhou Nursing Vocational College(No. gzhlyj2023-20), and Guizhou Nursing Association Youth Program(No. GZHLKYQ202505), and the Guizhou Provincial Basic Research Program (Natural Science) General Program and Key Program Projects (No. QKHJC-MS-[2025]007). The funders had no role in study design, data collection, data analysis, data interpretation, manuscript preparation, or the decision to submit the manuscript for publication.

Author Contribution

SL and ZJ conceptualized the study and developed the methodology. SL conducted the formal analysis, prepared the visualizations, curated the data, administered the project, and drafted the original manuscript. SL, GX, XY, SD, YQ, FC, JZ, and MZ contributed to the investigation. XY, SD, JZ, and MZ contributed to data curation. ZJ and YY supervised the study. ZJ, YQ, FC, and YY provided resources. ZJ acquired funding. All authors reviewed and edited the manuscript. All authors read and approved the final manuscript.

Data availability

The data supporting the findings are available from the corresponding author on reasonable request, subject to institutional and ethical approval.

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.
2. Hatch R, Young D, Barber V, Griffiths J, Harrison DA, Watkinson P. Anxiety, depression and post traumatic stress disorder after critical illness: a UK-wide prospective cohort study. *Crit Care*. 2018; 23;22(1):310.
3. Rabiee A, Nikayin S, Hashem MD, Huang M, Dinglas VD, Bienvenu OJ, et al. Depressive symptoms after critical illness: a systematic review and meta-analysis. *Crit Care Med*. 2016;44(9):1744–53.
4. Parker AM, Sricharoenchai T, Raparla S, Schneck KW, Bienvenu OJ, Needham DM. Posttraumatic stress disorder in critical illness survivors: a metaanalysis. *Crit Care Med*. 2015;43(5):1121–9.
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. 2018;46(9):e825–73.
6. Davidson JE, Aslakson RA, Long AC, Puntillo KA, Kross EK, Hart J, et al. Guidelines for family-centered care in the neonatal, pediatric, and adult ICU. *Crit Care Med*. 2017;45(1):103–28.
7. Jensen JF, Thomsen T, Overgaard D, Bestle MH, Christensen D, Egerod I. Impact of follow-up consultations for ICU survivors on post-ICU syndrome: a systematic review and meta-analysis. *Intensive Care Med*. 2015;41(5):763–75.
8. Barreto BB, Luz M, Rios MNO, Lopes AA, Gusmao-Flores D. The impact of intensive care unit diaries on patients' and relatives' outcomes: a systematic review and meta-analysis. *Crit Care*. 2019;23(1):411.
9. Garrouste-Orgeas M, Flahault C, Vinatier I, Rigaud JP, Thieulot-Rolin N, Mercier E, et al. Effect of an ICU diary on posttraumatic stress disorder symptoms among patients receiving mechanical ventilation: a randomized clinical trial. *JAMA*. 2019;322(3):229–39.
10. Bruno RR, Wolff G, Wernly B, Masyuk M, Piayda K, Leaver S, et al. Virtual and augmented reality in critical care medicine: the patient's, clinician's, and researcher's perspective. *Crit Care*. 2022;26(1):326.
11. Vlasek JH, van Bommel J, Wils EJ, Korevaar TIM, Bienvenu OJ, Klijn E, 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.
12. Drop DLQ, Vlasek JH, Wils EJ, Van Bommel J, Jung C, Hilling DE, et al. Effect of an intensive care unit virtual reality intervention on relatives' mental health distress: a multicenter, randomized controlled trial. *Crit Care*. 2025;29(1):62.
13. 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.
14. 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.
15. Cameron JI, Gignac MAM. Timing It Right: a conceptual framework for addressing the support needs of family caregivers to stroke survivors from the hospital to the home. *Patient Educ Couns*. 2008;70(3):305–14.
16. Yi M, Pan Y. Effects of Timing It Right nursing on clinical outcome and psychological resilience for lung cancer patients undergoing radical thoracoscopic surgery. *Am J Transl Res*. 2024;16(1):179–89.
17. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care*. 2007;19(6):349–57.
18. Brooke J. SUS-A quick and dirty usability scale[J]. *Usability Evaluation in Industry*; 1996. p. 189.

19. Li Q, Lin Y, Hu C, Xu Y, Zhou H, Yang L, et al. The Chinese version of hospital anxiety and depression scale: psychometric properties in Chinese cancer patients and their family caregivers. *Eur J Oncol Nurs*. 2016;25:16–23.
20. The development of the Chinese version of Impact of Event Scale-Revised (CIES-R). *Soc Psychiatry Psychiatr Epidemiol*. 2003;38(2):94–8.
21. Braun V, Clarke V. Using thematic analysis in psychology. *Qualitative Res Psychol*. 2006;3(2):77–101.
22. Schelling G, Richter M, Roozendaal B, Rothenhäusler HB, Krauseneck T, Stoll C, et al. Exposure to high stress in the intensive care unit may have negative effects on health-related quality-of-life outcomes after cardiac surgery. *Crit Care Med*. 2003;31(7):1971–80. 10.1097/01.CCM.0000069512.10544.40.
23. Jones C, Bäckman C, Capuzzo M, Egerod I, Flaatten H, Granja C, et al. Intensive care diaries reduce new onset post traumatic stress disorder following critical illness: a randomized, controlled trial. *Crit Care*. 2010;14(5):R168.
24. Mcllroy PA, King RS, Garrouste-Orgeas M, Tabah A, Ramanan M. The effect of ICU diaries on psychological outcomes and quality of life of survivors of critical illness and their relatives: a systematic review and meta-analysis. *Crit Care Med*. 2019;47(2):273–9.
25. Garrouste-Orgeas M, Coquet I, Périer A, Timsit JF, Pochard F, Lancrin F, et al. Impact of an intensive care unit diary on psychological distress in patients and relatives. *Crit Care Med*. 2012;40(7):2033–40.
26. Hill JE, Twamley J, Breed H, Kenyon R, Casey R, Zhang J, et al. Scoping review of the use of virtual reality in intensive care units. *Nurs Crit Care*. 2022;27(6):756–71.
27. Lee SY, Kang J. Effect of virtual reality meditation on sleep quality of intensive care unit patients: a randomized controlled trial. *Intensive Crit Care Nurs*. 2020;59:102849.
28. Hofhuis JGM, Spronk PE, van Stel HF, Schrijvers AJP, Rommes JH, Bakker J. Experiences of critically ill patients in the ICU. *Intensive Crit Care Nurs*. 2008;24(5):300–13.
29. Gezginici E, Goktas S, Orhan BN. The effects of environmental stressors in intensive care unit on anxiety and depression. *Nurs Crit Care*. 2022;27(1):113–9.
30. Oh J, Sohn JH, Shin CS, Na SH, Yoon HJ, Kim JJ, et al. Mutual relationship between anxiety and pain in the intensive care unit and its effect on medications. *J Crit Care*. 2015;30(5):1043–8.
31. Pochard F, Darmon M, Fassier T, Bollaert PE, Cheval C, Coloigner M, et al. Symptoms of anxiety and depression in family members of intensive care unit patients before discharge or death: a prospective multicenter study. *J Crit Care*. 2005;20(1):90–6.
32. Eysenbach G, CONSORT-EHEALTH Group. CONSORT-EHEALTH: improving and standardizing evaluation reports of web-based and mobile health interventions. *J Med Internet Res*. 2011;13(4):e126.
33. Brassel S, Power E, Campbell A, Brunner M, Togher L. Recommendations for the design and implementation of virtual reality clinical trials. *J Med Internet Res*. 2021;23(12):e26344.
34. Gravante F, Trotta F, Latina S, Simeone S, Alvaro R, Vellone E, et al. Quality of life in ICU survivors and their relatives with post-intensive care syndrome: a systematic review. *Nurs Crit Care*. 2024;29(4):807–23.
35. Ma Y, Yang X, Wang C, Li Y, Zhang Y, Wang L, et al. Comparative efficacy of non-pharmacological interventions for anxiety in adult intensive care unit patients: a systematic review and network meta-analysis. *Nurs Crit Care*. 2024;29(6):1334–45.
36. Elliott D, Davidson JE, Harvey MA, Bemis-Dougherty A, Hopkins RO, Iwashyna TJ, et al. Exploring the scope of post-intensive care syndrome therapy and care: engagement of non-critical care providers and survivors in a second stakeholders meeting. *Crit Care Med*. 2014;42(12):2518–26.
37. Turnbull AE, Rabiee A, Davis WE, Nasser MF, Venna VR, Lolitha R, et al. Outcome measurement in ICU survivorship research from 1970 to 2013: a scoping review of 425 publications. *Crit Care Med*. 2016;44(7):1267–77.
38. Harvey MA, Davidson JE. Post-intensive care syndrome: right care, right now... and later. *Crit Care Med*. 2016;44(2):381–385.
39. Azoulay E, Vincent JL, Angus DC, Arabi YM, Brochard L, Brett SJ, et al. Recovery after critical illness: putting the puzzle together—a consensus of 29. *Crit Care*. 2017;21(1):296.

Figures

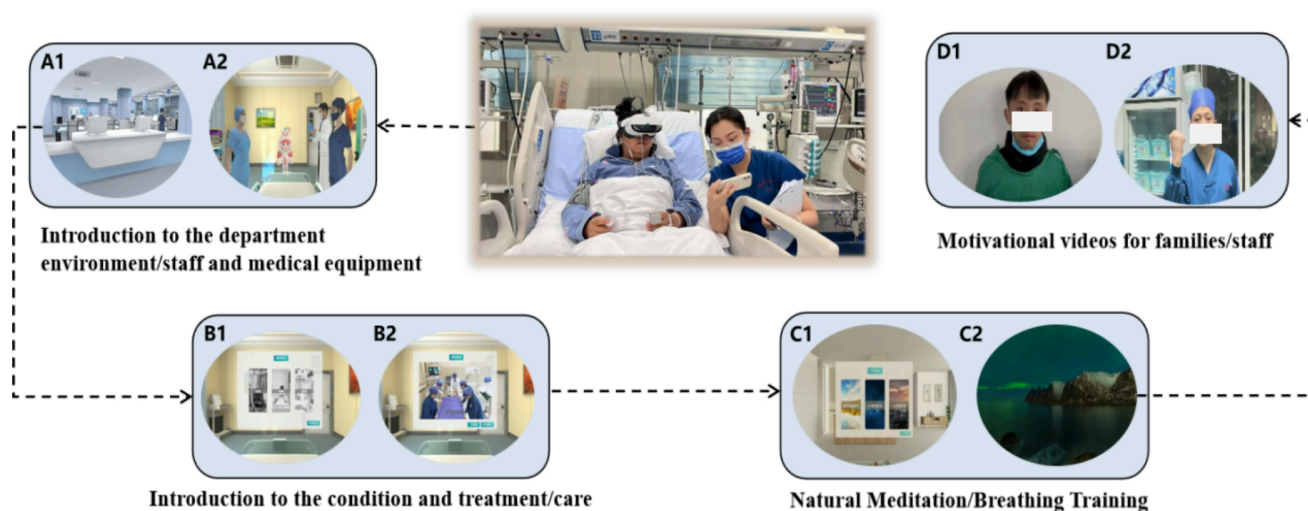


Figure 1

Components and phase-matched delivery of the investigator-developed virtual reality support system

Figure 2. Participant flow through the study.

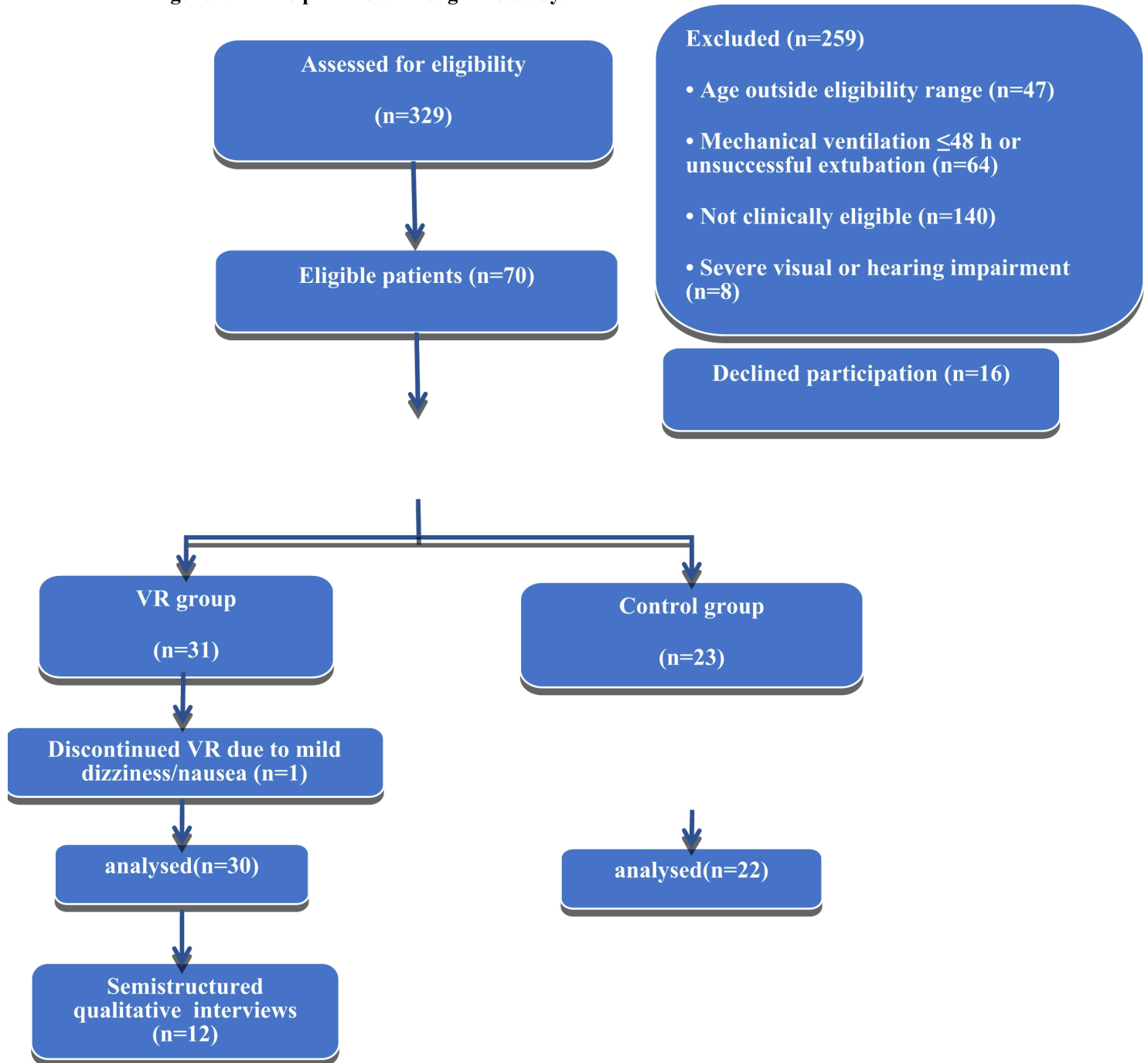


Figure 2

See image above for figure legend

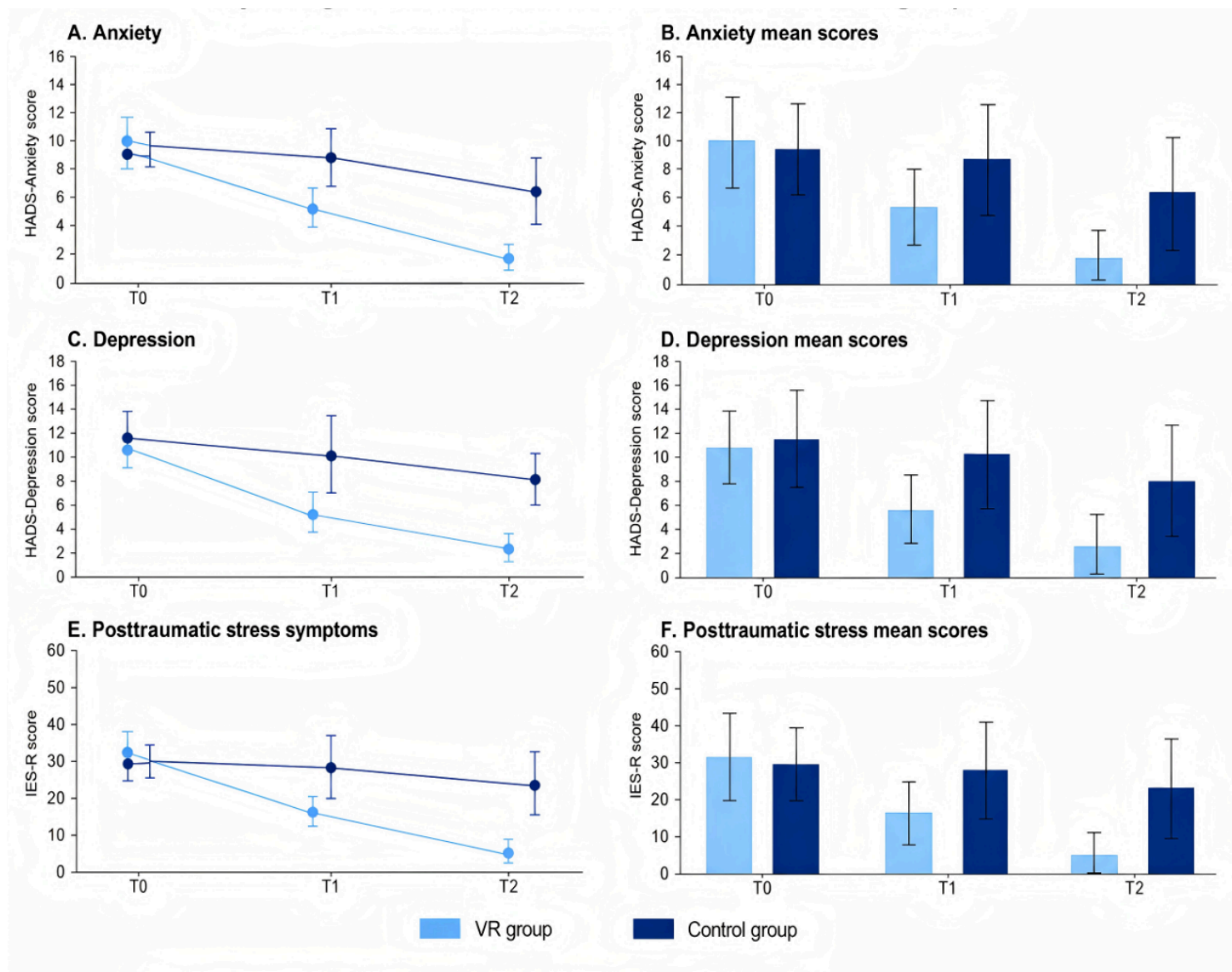


Figure 3

Trajectories of exploratory psychological outcomes in the VR and control groups

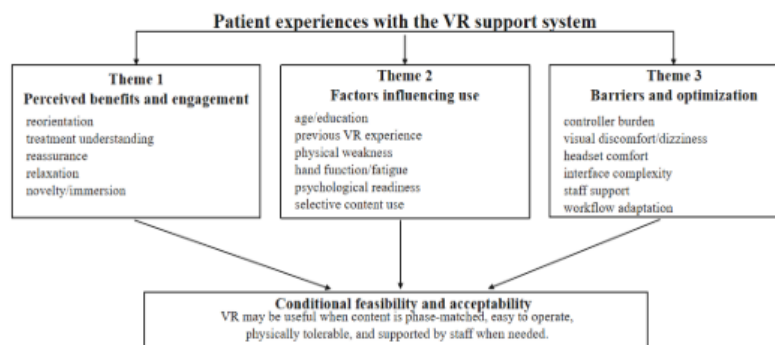


Figure 4

Thematic map of patient experiences with the VR support system

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryFile1.docx](#)
- [SupplementaryFile2.docx](#)
- [SupplementaryFile3.docx](#)