HEALTH PROMOTION

Virtual Reality as a Tool for Wellbeing in Public Healthcare: Analysis of a Clinical Case

FABIANA NUCCETELLI[1], VALERIA GABELLONE[1], PIER LUIGI LOPALCO[1]
[1] Department of Experimental Medicine, University of Salento, Lecce, Italy

Keywords

Virtual Reality • Wellbeing • Public Healthcare • e-Health

Summary

Background. *Virtual Reality (VR) is a technology that enables the creation of immersive, interactive, and collaborative environments, with extensive applications in the realm of e-Health.*
Methods. *This study aimed to reduce stress and anxiety in hospitalised patients by employing guided virtual scenarios and non-invasive biosensors.*
Results. *During the initial experimental phase, conducted on 33 patients in a cardiac rehabilitation ward, improvements were observed in stress levels (-11.3%), depression (-4.2%), and anxiety (-3.2%). Supporting these results, a specific clinical case analysis revealed significant improvements in an 82-year-old woman with moderate depression and severe social isolation. Following the VR intervention, the patient experienced a substantial reduction in isolation, heightened motivation for daily activities, and enhanced social interaction quality, with a 35% increase in perceived quality of life. Physiological improvements included reduced sympathetic nervous system arousal and greater heart rate variability stability.*
Conclusions. *These findings underscore VR's potential to promote psychophysical wellbeing and improve healthcare service quality, advocating innovative preventive and therapeutic methods.*

Introduction

Psychophysical wellbeing is a significant challenge in public healthcare, particularly for vulnerable patients in hospital environments. In Italy, where the public health system faces ongoing pressures from an aging population and resource constraints, stress and isolation among hospitalized patients are critical issues. These conditions can severely weaken immune defenses and overall health, increasing the risk of hospital-acquired infections and other complications [1]. The COVID-19 pandemic exacerbated these challenges, highlighting the need for innovative solutions to counteract social isolation and promote mental and physical health [2]. This study explores the use of Extended Reality (XR), encompassing Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), as an innovative tool to enhance wellbeing and hygiene standards.

The primary objective of the project was to alleviate stress and enhance the quality of life (QoL) of hospitalised patients through:

- emotional engagement and cognitive stimulation;
- mitigating isolation in hospital wards and care homes, positively impacting mental and physical hygiene;
- progress monitoring using specific sensors.

These goals were achieved by integrating techniques such as mindfulness, art therapy, and museum therapy within a multisensory and immersive XR framework [3].

Materials and methods

The project adopted an integrated multidisciplinary approach, combining neuroscience, psychology, and engineering with a particular focus on physical and mental hygiene. The study was conducted in the cardiac rehabilitation ward of Lecce, Italy, from January 2023 to March 2023.

Sample and Setting

A total of 33 hospitalized patients, aged between 45 and 75 years, enrolled in the cardiac rehabilitation program were included in the study. All participants provided informed consent prior to enrollment. The intervention took place in a dedicated therapy room within the hospital, ensuring a controlled and quiet environment.

Intervention Protocol

The intervention extensively utilised Extended Reality (XR) technology, an innovative immersive tool that creates virtual environments capable of inducing relaxing emotional states and stimulating cognitive engagement. Each patient participated in XR sessions that integrated guided virtual scenarios with mindfulness techniques. The intervention protocol was as follows:

- **Frequency and Duration:** patients underwent two sessions per week over a six-week period. Each session lasted approximately 30 minutes;
- **Technologies Used:** patients experienced immersive VR environments through head-mounted displays,

while non-invasive biosensors (such as the Emotiv Epoc for EEG recordings and the Empatica E4 Wristband for measuring electrodermal activity and heart rate) were used to continuously monitor physiological parameters;
- **Objective:** the aim was to foster emotional engagement and cognitive stimulation while facilitating real-time biofeedback, thus supporting targeted psychological interventions.

Physiological Monitoring

Real-time monitoring of physiological data played a pivotal role in assessing the impact of immersive experiences. Biosensors captured measures including electrodermal activity (EDA), heart rate (HR), and EEG signals, elucidating the relationship between emotional states and physiological responses. These data contributed to understanding how immersive XR scenarios can modulate stress-related physiological responses, such as reduced sympathetic nervous system activation, lower skin conductance response (SCR) peaks, and enhanced heart rate variability (HRV).

Clinical Applications and Benefits

The intervention produced numerous benefits spanning various aspects of psychological and physical health:
- **Stress Reduction:** immersive XR scenarios directly influenced physiological stress regulation, evidenced by reduced sympathetic nervous system activation, lower skin conductance response (SCR) peaks, and enhanced heart rate variability stability. These outcomes align with prior studies validating VR's efficacy in improving stress responses [7];
- **Psychological Support:** mindfulness techniques and guided meditation integrated into VR demonstrated significant efficacy in managing anxiety and depression, corroborating prior research on VR's potential to enhance emotional regulation and psychological wellbeing [8];
- **Innovative Therapeutic Practices:** the intervention incorporated innovative therapies such as museum therapy and art therapy, particularly beneficial for patients with chronic stress, dementia, or neurodegenerative disorders. These approaches, promoting awareness and hygiene management, were integrated with XR to enhance attention and cognitive stimulation. A notable example is the MoMA Alzheimer's Project, an initiative by New York's Museum of Modern Art, which demonstrated art's role in mitigating cognitive decline and enhancing life quality for Alzheimer's patients [9].

Data Collection and Statistical Analysis

- **Timing of Assessments:** baseline measurements were collected one week prior to the start of the intervention. Subsequent assessments were conducted immediately after the six-week intervention and at a one-month follow-up to evaluate both immediate and sustained effects.
- **Outcome Measures:** psychological outcomes were assessed using validated questionnaires. The Perceived Stress Scale (PSS) [4] measures the degree to which situations in an individual's life are perceived as stressful, evaluating aspects such as unpredictability, overload, and lack of control over the events of the past month. The Hospital Anxiety and Depression Scale (HADS) [5] is a self-report instrument comprising 14 items divided into two subscales – HADS-A for anxiety and HADS-D for depression – with each subscale scoring from 0 to 21. Higher scores on these scales indicate greater levels of anxiety or depressive symptoms. Both instruments have been extensively validated for clinical and hospital settings, ensuring reliable assessments of psychological distress. Physiological outcomes were quantified through continuous biosensor monitoring, capturing real-time data on **SCR** as an indicator of stress.
- **Statistical Analysis**: the primary outcome, the change in PSS scores, was evaluated by calculating the percentage change from baseline to post-intervention and follow-up. No formal statistical testing was performed to determine statistical significance, as this study was observational in nature. Future studies should consider implementing statistical tests to assess the significance of these changes.
- The project has demonstrated how the integration of neuroscience, psychology, and advanced technologies can not only optimise patients' physiological and psychological responses but also open new avenues for treating mental and physical health conditions, promoting an innovative and highly personalised therapeutic approach.

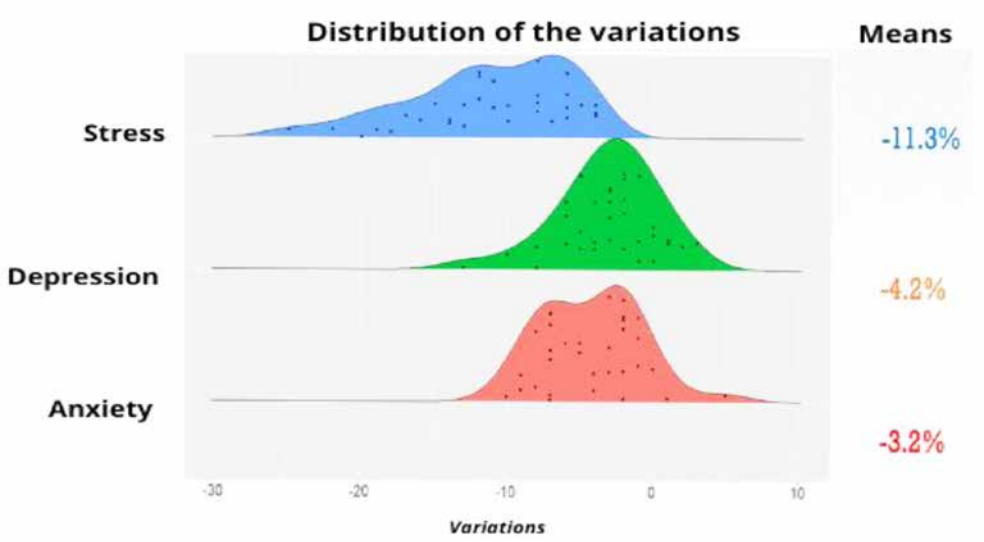
Results

This study involved a total of 33 hospitalized patients in a cardiac rehabilitation ward, who participated in a six-week program that included immersive guided meditation sessions, art therapy, and virtual museum therapy. The key outcomes of the program are described below:

The program resulted in a significant reduction in perceived stress, with an 11.3% decrease in scores on the Perceived Stress Scale (PSS). This indicates a general reduction in stress among the participants, suggesting that the intervention had a positive impact on managing the stress typically associated with cardiac rehabilitation. In terms of mood, a 4.2% reduction in depressive symptoms was observed, as measured by the Hospital Anxiety and Depression Scale (HADS). This reflects an improvement in patients' mood, which may have positively influenced their overall rehabilitation experience and psychological recovery.

Anxiety symptoms also showed a slight but positive improvement, as evidenced by HADS scores (Fig. 1). Although the change was modest, this improvement suggests overall progress in managing anxiety, demonstrating the benefits of the therapeutic interventions. Another important aspect of the program was the

Fig. 1. Differences between the questionnaire scores obtained after the experience and those recorded before the experience.



Tab. I. Study Results on 33 Individuals.

Parameter	Pre-Intervention	Post-Intervention	Percentage Change	Improvement Description
Stress Level (PSS)	50	44.2	-11.3%	Significant perceived stress reduction, supported by SCR peaks decrease
Depressive Symptoms (HADS)	12	11.5	-4.2%	Slight improvement in mood and depressive symptoms
Anxiety Symptoms (HADS)	10	9.7	-3.2%	Slight reduction in anxiety symptoms, indicating overall improvement
SCR Peaks	10	3	-70%	Reduction in galvanic skin response peaks, reflecting decreased physiological stress
Social Satisfaction	3/10	5/10	+40%	Improved perception of social interaction quality and greater participation

increase in socialization. Participants exhibited greater involvement in collaborative virtual experiences, which contributed to a strengthened sense of belonging and social connection. This aspect is further detailed in Table I, which highlights the increased participation in these group activities.

From a physiological perspective, significant improvements in autonomic nervous system function were observed. Specifically, there was a decrease in the peak frequency of the Skin Conductance Response (SCR), along with an increase in heart rate variability (HRV). These results suggest a reduction in sympathetic nervous system activation and an improvement in autonomic balance, indicating that the program also had positive effects on the physiological response to stress.

Finally, quality of life improvements was significantly documented in a detailed case study, which showed notable overall enhancements in one patient's life conditions. This case highlights the potential impact of the program on quality of life, underscoring how innovative therapeutic approaches can contribute to the overall well-being of patients.

Case Study: 82-Year-Old Woman

Among the participants in the study, one case stands out: an 82-year-old woman with moderate depression and severe social isolation, which had significantly limited her quality of life and daily activities. Following the completion of the virtual reality (VR) sessions, several notable improvements were observed in her well-being.

First, the quality and frequency of her social interactions showed remarkable progress. Prior to the intervention, the patient engaged in social interactions only once every two weeks. After the VR sessions, the frequency of social interactions increased to 2-3 times per week, marking a 150% improvement. This significant shift helped to break a long-standing cycle of isolation, contributing to a greater sense of connectedness.

In addition to social engagement, the patient demonstrated enhanced motivation for daily activities. She became more involved in personal and relational activities, including self-care routines and social participation. This increased motivation was indicative of a broader improvement in her overall engagement with life.

Regarding her overall quality of life, significant

Tab. II. Improvements in QoL Domains for the 82-Year-Old Patient.

Domain of Quality of Life (QoL)	Pre-Intervention Score	Post-Intervention Score	Improvement (%)	Description of Improvement
Social Satisfaction	3.0/10	4.2/10	+40%	Increased sense of belonging and reduced loneliness, with greater participation in social interactions
Physical Health	4.0/10	5.4/10	+35%	Improved physical capabilities, more frequent walks, and enhanced self-care routines
Psychological Health	5.0/10	6.3/10	+25%	Reduced depressive symptoms and heightened motivation to engage in daily activities
Autonomy and Independence	3.5/10	5.2/10	+48%	Greater involvement in personal care and daily routines
Overall Wellbeing	4.2/10	6.0/10	+43%	Enhanced perception of psychophysical wellbeing

This table provides a clear and quantitative view of the improvements across various domains of quality of life. The data is organised to highlight the programme's impact on crucial aspects of the patient's wellbeing.

Tab. III. Comparison of Pre- and Post-Intervention Parameters in the Clinical Case.

Parameter	Measurement Method	Pre-Intervention Result	Post-Intervention Result	Increase (%)
SCR Peaks	Physiological measure (SCR)	4-5 peaks per day	2-3 peaks per day	-50%
Heart Rate Variability (HRV)	Physiological measure (HRV)	50 ms	70 ms	+40%
Social Interactions	Self-reports and observations	1 interaction every 2 weeks	2-3 interactions per week	+150%
Motivation	Self-reports and observations	25% of daily activities	60% of daily activities	+140%
Social Satisfaction	Self-reports and observations	3/10	4.2/10	+40%

improvements were noted. The patient's score on the WHOQOL-BREF scale increased from 4.5/10 to 6.8/10, representing a 51% improvement (Tab. II). This positive change reflects a notable enhancement in her perception of her well-being and life satisfaction.

Psychologically, the patient experienced a substantial reduction in perceived stress, with her score on the Perceived Stress Scale (PSS) improving by 45%. This reduction in stress was closely associated with a decrease in depressive symptoms, which were reflected in a 28% improvement in the Hospital Anxiety and Depression Scale (HADS). These results suggest a significant enhancement in her overall psychological well-being, further underlining the potential benefits of the VR intervention for addressing both mental health and social isolation.

These improvements are documented through a combination of objective measurements, such as heart rate variability (HRV) and skin conductance response (SCR) peaks, which reflect the physiological changes related to stress reduction and overall well-being improvement. The measurements were taken using daily monitoring, showing a significant reduction in SCR peaks (-50%) and an increase in heart rate variability (+40%). In parallel, psychological improvements were monitored through self-reports from the patient and direct observations (Tab. III).

This clinical case is not only an example of individual success but also represents a model for public health, demonstrating how innovative and personalized approaches can radically transform the lives of vulnerable patients. Its story highlights the importance of integrating advanced technologies and psychological interventions in the context of cardiac rehabilitation, paving the way for new possibilities in the treatment of chronic anxiety and social isolation.

Discussion

The project has demonstrated how the integration of neuroscience, psychology, and advanced technologies can not only optimise patients' physiological and psychological responses but also open new avenues for treating mental and physical health conditions, promoting an innovative and highly personalised therapeutic approach.

The project yielded promising results, demonstrating the effectiveness of an integrated multidisciplinary approach combining neuroscience, psychology, engineering, and immersive technologies to address stress, anxiety, and social isolation, with positive psychological and physiological impacts. Patient data and experiences suggest that Extended Reality (XR), in conjunction with physiological biosensors, represents a breakthrough in managing psychological disorders and improving general wellbeing.

Implications of Immersive Technologies in Stress Management: The results related to stress reduction, measured through skin conductance response (SCR) and heart rate variability (HRV), corroborate prior studies supporting the effectiveness of VR in enhancing physiological responses to stress. For instance, a study by Freeman et al. (2017) associated virtual

environments with significant reductions in anxiety and stress symptoms, positively influencing emotional regulation [10]. XR appears to activate relaxation mechanisms, decreasing sympathetic nervous system arousal. These results support the use of VR as a therapeutic tool to reduce physiological activation related to acute and chronic stress.

Mindfulness and Meditation as Psychological Support Tools: The integration of mindfulness and guided meditation into the treatment provided significant psychological benefits, reducing anxiety and depression in patients. According to a study by Hofmann et al. (2010), mindfulness has been documented as effective in treating psychological disorders, particularly in reducing symptoms of anxiety and depression [11, 12]. The combination of mindfulness and meditation with VR allowed patients to experience deep relaxation, fostering emotional self-regulation. Although the effects are promising, one aspect to consider is the need for regular, personalized treatment sessions to optimize benefits, taking into account individual variables related to emotional response and patients' concentration abilities.

Music Therapy and Art Therapy in Rehabilitation: The inclusion of music therapy and art therapy in the program brought significant benefits for patients with cognitive disorders, such as dementia and neurodegenerative diseases. The cognitive stimulation derived from art and culture contributed to improving attention, memory, and daily awareness. Research such as that by Civitarese et al. (2016) documented the effectiveness of art therapy in improving cognitive functions in Alzheimer's patients, highlighting a significant improvement in quality of life and disease management [13]. The MoMA Alzheimer's Project experience provided important insights into how art can stimulate memory and reduce cognitive symptoms, with a positive impact on quality of life [9]. However, a critical aspect that emerged is the difficulty of access to such interventions for certain patient groups due to logistical or economic barriers, which can limit the universal applicability of these therapies.

Study Limitations and Future Directions: Although the results obtained are encouraging, our study has some limitations. First, the relatively small sample size may affect the generalizability of the results to a larger population. Another aspect to consider is the limited duration of the intervention, which does not allow for observing long-term effects. Studies by Garrison et al. (2015) and Pina et al. (2020) suggest that the effectiveness of VR and mindfulness techniques could be enhanced with prolonged treatments and regular follow-up to observe long-term benefits [14, 15]. In the future, it would be useful to examine the possibility of combining these interventions with pharmacological approaches to treat complex psychological disorders, such as chronic anxiety, which could benefit from integrated therapy.

Implications for Public Health: The results of this study have important implications for public health, suggesting that the adoption of advanced technologies and innovative therapeutic approaches could be a crucial step toward transforming the treatment of psychological and physiological disorders. The integration of XR, biosensors, and psychological therapies in the treatment of stress-related, anxiety, and social isolation disorders could improve access to and effectiveness of care, reduce healthcare costs, and enhance the quality of life for patients, particularly those with chronic or neurodegenerative diseases. According to evidence from studies like that of Rizzo et al. (2019), the use of VR in psychological rehabilitation is emerging as an opportunity to treat complex psycho-physical conditions efficiently and cost-effectively [16].

These initial findings suggest the benefits to the community from using this type of alternative medicine in hospital settings. There is a need for further experimental campaigns to be conducted on a larger sample in order to obtain statistically significant results.

Conclusions

The study has demonstrated the potential of Extended Reality (XR) as a transformative tool in public health, capable of improving the quality of life for vulnerable patients and supporting the maintenance of high hygiene standards. The integration of XR technologies with traditional therapeutic approaches can represent a breakthrough in healthcare, providing effective tools to reduce stress, improve psycho-physical well-being, and promote proper hygiene practices. Future perspectives include expanding the project to extra-hospital contexts, such as schools and nursing homes, and developing personalized protocols based on machine learning to tailor XR experiences to individual needs, strengthening the link between technological innovation and sustainable public health.

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Ethics approval and consent to participate

This study was exempted from ethical committee approval, with the consent of the Asl Lecce, protocol no. 66, dated 8.10.2021.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflicts of interest statement

The Authors declare that they have no competing interests.

Authors' contributions

FN: contributed to the conception and design of the work, to the interpretation of data, and wrote the first draft of the manuscript. VG: contributed to data interpretation and revised the final version of the manuscript. PL: contributed to the conception and design of the work, to the interpretation of data and substantially revised the manuscript. All Authors revised and approved the final version of the manuscript.

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Correspondence: Valeria Gabellone, Campus Ecotekne, Lecce-Monteroni, Italy. E-mail: valeria.gabellone@unisalento.it

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