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ORIGINAL ARTICLE

# Application of a multisensory environment in the ICU: Effect on delirium and circadian rhythm regulation

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**KEYWORDS**
Delirium;
Intensive care;
Circadian rhythm;
Multisensory environment;
Sedation;
Non-pharmacological intervention

**Abstract**
*Objective:* To evaluate the impact of a multisensory environmental intervention designed to simulate and synchronize physiological circadian rhythms on the incidence of delirium and other clinical outcomes in critically ill patients admitted to an intensive care unit (ICU).
*Design:* Pre-post quasi-experimental study without randomization, conducted between September 2023 and June 2024.
*Setting:* Adult Intensive Care Unit in a tertiary university hospital.
*Patients:* 538 consecutive patients were included: 251 during the control period and 287 after implementation of the intervention.
*Intervention:* Installation of the SHX® environmental stimulation system, which provides programmed transitions of light, image, and sound simulating sunrise and sunset, aimed at supporting circadian synchronization.
*Main outcome variables:* Incidence of delirium (assessed using the CAM-ICU tool), levels of sedation-agitation (RASS scale), and daily consumption of sedative drugs per day of ICU stay.
*Results:* A non-significant reduction in the incidence of delirium was observed (14.3% vs. 9.1%; $P = .075$), along with a significant redistribution in sedation-agitation levels ($P < .001$) and a significant decrease in daily midazolam consumption per day of stay (9.6 mg vs. 3.8 mg; $P = .019$).
*Conclusions:* The implementation of a multisensory environment synchronized with the circadian rhythm was associated with improvements in delirium-related outcomes, sedation-agitation profiles, and benzodiazepine use. These findings support the use of non-pharmacological environmental interventions as complementary tools in the prevention of ICU delirium.
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**PALABRAS CLAVE**
Delirium;
Cuidados intensivos;
Ritmo circadiano;
Entorno multisensorial;
Sedación;
Intervención no farmacológica

**Aplicación de un entorno multisensorial en la UCI: efecto sobre el delirium y la regulación del ritmo circadiano**

**Resumen**
*Objetivo:* Evaluar el impacto de una intervención ambiental multisensorial, diseñada para simular y sincronizar los ritmos circadianos fisiológicos, sobre la incidencia de delirium y otros desenlaces clínicos en pacientes críticos ingresados en una unidad de cuidados intensivos (UCI).
*Diseño:* Estudio cuasiexperimental pre-post intervención, sin aleatorización, realizado entre septiembre de 2023 y junio de 2024.
*Ámbito:* UCI de adultos en un hospital universitario de tercer nivel.
*Pacientes:* Se estudiaron 538 pacientes ingresados de forma consecutiva: 251 en el periodo control y 287 tras la implementación de la intervención.
*Intervenciones:* Instalación del sistema SHX® de estimulación ambiental, que reproduce de forma programada transiciones de luz, imagen y sonido asociadas al amanecer y al anochecer, con el objetivo de favorecer la sincronización circadiana.
*Variables de interés principales:* Incidencia de delirium (evaluado con la herramienta Confusion Assessment Method for the Intensive Care Unit [CAM-ICU]), niveles de sedación-agitación (escala *Richmond Agitation-Sedation Scale* [RASS]) y consumo diario de fármacos sedantes por día de estancia.
*Resultados:* Se observó una reducción no significativa en la incidencia de delirium (14,3% vs. 9,1%; $P = ,075$), una redistribución significativa del perfil de sedación-agitación ($P < ,001$) y una disminución significativa en el consumo diario de midazolam por día de estancia (9,6 mg vs. 3,8 mg; $P = ,019$).
*Conclusiones:* La implementación de un entorno multisensorial sincronizado con el ritmo circadiano se asoció con mejoras en variables relacionadas con el delirium, el nivel de sedación-agitación y el uso de benzodiacepinas. Estos hallazgos apoyan el uso de intervenciones ambientales no farmacológicas como complemento en la prevención del delirium en UCI.
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Delirium is an acute neurological disorder characterized by a sudden onset and fluctuating course, presenting as a global disturbance in attention, awareness, and cognition. The PADIS (Pain, Anxiety, Agitation/Sedation, Delirium, Immobility, and Sleep Disruption) guidelines of the Society of Critical Care Medicine define delirium as a form of acute organ dysfunction of the brain in critically ill patients, with relevant clinical implications and potential preventability.[1] In the intensive care unit (ICU) setting, its incidence ranges from 30% to 80%, depending on patient characteristics and the diagnostic methods used.[2,3] Its presence has been independently associated with increased morbidity and mortality, longer duration of mechanical ventilation and ICU stay, and persistent cognitive impairment after hospital discharge, with a significant impact on quality-of-life.[2–5]

The development of delirium in critically ill patients is a result of a complex interaction between patient-related and environmental factors. Predisposing factors include advanced age, frailty, and preexisting cognitive impairment. Precipitating factors comprise hypoxemia, sepsis, prolonged immobilization, sleep deprivation, and exposure to specific medications—particularly benzodiazepines.[1,2,4,6] Deep sedation has consistently been identified as a particularly relevant and modifiable risk factor. Although indicated during specific phases of ventilatory support, its prolonged use has been linked to a higher incidence of delirium,[7] especially in patients with low functional reserve or prolonged mechanical ventilation.[3,8]

The physical and sensory environment of the ICU plays an important role in the onset and progression of delirium.[9,10] Although designed to provide continuous monitoring and advanced life support, the environmental conditions they generate—such as sustained exposure to artificial light, high noise levels, and frequent sleep interruptions due to care activities—profoundly disrupt the patient's circadian rhythm.[6,11,12] Moreover, the ICU sensory environment is often poorly adapted to the neurocognitive needs of critically ill patients, hindering recovery and contributing to neurological complications such as delirium.[13] Circadian rhythm disruption has been linked to suppression of nocturnal melatonin secretion and significant alterations in circadian synchronization mechanisms.[6,11,12,14–18] These changes promote disturbances in temporal and spatial orientation, as well as acute cognitive dysfunction, facilitating the onset of delirium during ICU admission.[9,17]

Circadian rhythm disruption is considered a potential contributing factor in the development of delirium in critically ill patients.[6,9,12,14,18] This hypothesis has motivated the evaluation of nonpharmacologic interventions aimed at preserving or restoring circadian synchronization by modu-

lating environmental sensory stimuli. Described strategies include controlling light–dark cycles, reducing environmental noise, reorganizing clinical routines, implementing sleep-hygiene measures, and chronotherapy.[9,10,15–17,19,20] In addition, certain positive sensory stimuli, such as music therapy, may improve emotional adaptation and reduce anxiety, playing a complementary role in delirium prevention.[21] Current evidence suggests that these interventions are associated with a lower incidence rate of delirium and improved sleep quality.[9,10,20] Furthermore, they form part of a care model that recognizes the importance of the physical and sensory environment in preserving higher neurological functions in critically ill patients. The ABCDEF bundle has emerged as an effective strategy to structure complex interventions in ICU patients, aiming to improve clinical and functional outcomes.[15] This model incorporates systematic delirium monitoring, pain assessment and management, optimization of sedation, early mobilization, promotion of rest, and engagement of family members in the care process.[6,12,15,22] Its implementation has been associated with lower delirium incidence rate, reduced mechanical ventilation duration, and improved functional outcomes at discharge.[15,22] Despite increasing recognition of the importance of preserving circadian rhythmicity in critically ill patients,[10] such interventions remain rare in clinical practice, variably implemented, and often lacking standardized protocols. This underscores the need for more structured strategies integrating these measures into routine care. In this context, redesigning ICUs with a patient-centered perspective—where the physical environment actively supports recovery through elements such as optimized lighting, therapeutic quiet, temporal orientation cues, and improved spatial aesthetics—has been proposed.[23] Environmental modulation—through light–dark cycle control, noise reduction, and scheduled timing of care interventions—is an expanding strategy with growing clinical interest and organizational feasibility. Although evidence has advanced in recent years, key questions remain regarding the comparative effectiveness, real-world applicability, and optimal integration of these strategies into delirium management.

The objective of this study was to evaluate the impact of a multisensory environmental intervention designed to promote circadian synchronization on the incidence of delirium.

## Patients and methods

We conducted a quasi-experimental study in a tertiary ICU including all patients admitted for more than 24 h, structured into two periods: a preintervention phase (September 1st, 2023–January 31st, 2024) and a postintervention phase (February 1st–June 30th, 2024). In the 2nd phase, the SHX® multisensory stimulation system—designed to simulate environmental sunrise and sunset cycles in each ICU room—was implemented. The intervention aimed to support circadian synchronization in critically ill patients through controlled illumination mimicking natural light–dark transitions. The primary endpoint was to analyze the effect of the multisensory intervention on delirium incidence rate, assessed using the Confusion Assessment Method for the ICU (CAM-ICU). Delirium was monitored systematically during each nursing shift. Secondary endpoints were to describe and compare agitation-sedation profiles via the Richmond Agitation–Sedation Scale (RASS) and sedative and antipsychotic drug use adjusted for ICU stay between the control and intervention periods.

The SHX® multisensory stimulation system is designed to modulate ambient lighting, allowing progressive adjustment of light intensity to simulate the natural transitions of dawn and dusk. In addition, the system incorporates real-time audiovisual content that reproduces sunrise and sunset scenes, projected on screens at 08:45 h and 21:30 h, respectively. This projection is complemented by the emission of environmental sounds through speakers, creating an immersive experience intended to improve patient adaptation to the ICU environment. The individualization of the system is managed through a tablet connected to the internal SHX® network, allowing precise, real-time adjustment of stimuli. Furthermore, the lighting in the ICU's common areas was synchronized with the system to decrease its intensity during nighttime hours and increase it during daytime hours.

Before the start of the 2nd study period, a specific online course on Multisensory Therapy applied to the ICU and on the technical settings of the SHX® system was developed. The course, hosted on the hospital's educational platform and accessible to all professionals in the critical care area, included theoretical and practical contents aimed at standardizing the application of the intervention and ensuring its uniform implementation.

No manual monitoring of compliance was performed, since the sunrise and sunset cycles were automated through the system controlling light and sound, ensuring continuous and standardized application. The intervention remained active throughout the patient's ICU stay, except for specific interruptions due to exceptional clinical reasons. For each patient, relevant demographic and clinical variables were collected, including the APACHE II score at admission as a measure of severity, the reason for admission, the need for mechanical ventilation and its duration, as well as the use of analgesic-sedative drugs, antipsychotics, and benzodiazepines, adjusting the total consumption of each drug (in mg or mcg) to the total number of days of stay in each period.

The level of agitation–sedation was assessed using the RASS. Delirium was diagnosed systematically during each nursing shift using the CAM-ICU tool during both study periods. The primary variable was defined as the cumulative incidence of delirium during the ICU stay, considering the occurrence of at least one positive episode at any point during admission.

Given the initial and exploratory design of the study, no formal sample-size calculation was performed. Only a preliminary estimation was made to detect a reduction in delirium incidence from 30% to 20% ($\alpha = 0.05$; power = 80%), which suggested the need for approximately 294 patients per group. For logistical reasons and in line with the exploratory design, all consecutive patients in the two predefined care periods were included.

To compare characteristics and outcomes between the two study periods (pre-intervention and post-intervention), Student's *t*-test for independent samples for quantitative variables with normal distribution, and the chi-square test for categorical variables were used. A *P*-value <.05 was

**Table 1** Clinical and demographic characteristics of patients in the control and intervention periods.

| Variable | Control period (n = 251) | Intervention period (n = 287) | *P* value |
|---|---|---|---|
| Sex (M/F) | 66.1%/33.9% | 73.9%/26.1% | .057 |
| Age (years) | 63.8 ± 12.78 | 64.5 ± 12 | .55 |
| APACHE II | 24.5 ± 8.23 | 25.3 ± 8.44 | .43 |
| Length of the ICU stay (days) | 8.4 ± 10.54 | 7.79 ± 9.53 | .46 |
| Emergency/scheduled admission | 48.5%/51.5% | 43.7%/56.3% | .3 |
| Medical/surgical admission | 36.7%/63.3% | 33.7%/66.3% | .5 |
| Days on MV | 19.1 ± 52.6 | 16.3 ± 44.6 | .49 |
| Delirium (%) | 14.34% | 9.06% | .075 |

ICU: Intensive Care Unit; MV: mechanical ventilation.

**Table 2** Distribution of RASS Scores in the Control and Intervention Periods.

| RASS | Control period | Intervention period | Total |
|---|---|---|---|
| −5 Unarousable | 858 | 1026 | 1884 |
| −4 Deep sedation | 1475 | 1410 | 2885 |
| −3 Moderate sedation | 1315 | 905 | 2220 |
| −2 Light sedation | 764 | 645 | 1409 |
| −1 Drowsy | 1170 | 1016 | 2186 |
| 0 Alert and calm | 6574 | 7271 | 13,845 |
| +1 Restless | 689 | 508 | 1197 |
| +2 Agitated | 41 | 24 | 65 |
| +3 Very agitated | 2 | 3 | 5 |
| +4 Combative | 4 | 3 | 7 |

RASS: Richmond Agitation–Sedation Scale.

considered statistically significant. Statistical analysis was performed using IBM® SPSS® Statistics, version 25.0 (IBM Corp., Armonk, NY, United States).

The study was approved by the Clinical Research Ethics Committee (PR150/23). All adult patients admitted to the ICU with an expected stay > 24 h were included. The intervention was considered low-risk and integrated into routine care; therefore, no specific consent was required for its application. Informed consent was limited to the use of clinical data for scientific purposes, in accordance with the CEIC requirements stated in its approval.

## Results

A total of 538 patients were included, distributed across two consecutive periods: 251 in the control period (without environmental intervention) and 287 in the test period (with multisensory environmental intervention). Baseline demographic and clinical characteristics are summarized in Table 1. No statistically differences were observed between groups in terms of age (63.8 ± 12.8 years vs 64.5 ± 12 years; *P* = .55), APACHE II score (24.5 ± 8.2 vs 25.3 ± 8.4; *P* = .43), length of ICU stay (8.4 ± 10.5 days vs 7.8 ± 9.5 days; *P* = .46), or time on mechanical ventilation (19.1 ± 52.6 days vs 16.3 ± 44.6 days; *P* = .49). No significant differences were found regarding type of admission (surgical vs medical; *P* = .50) nor whether the admission was scheduled or urgent (*P* = .30), suggesting a homogeneous distribution between groups.

The incidence rate of delirium diagnosed using CAM-ICU was 14.34% in the control period and 9.06% in the intervention period. The difference between periods did not reach statistical significance (*P* = .075), although a 5.28% reduction in delirium incidence was observed in the intervention group. The distribution of sedation and agitation levels, assessed using the RASS scale, is shown in Table 2. The most frequent category in both groups was ''alert and calm'' (RASS 0), with 6574 records in the control period and 7271 in the intervention period. Other categories, such as moderate sedation (RASS −3), light sedation (RASS −2), and mild agitation (RASS + 1), showed a decrease in the intervention period compared with the control period. The chi-square test of independence applied to the frequency distribution of RASS categories showed statistically significant differences between the two groups (chi-square test = 180.06; df = 9; *P* < .001).

Regarding the use of sedative, analgesic, and antipsychotic drugs adjusted to ICU days in each period (Table 3), a general reduction in administered doses was observed during the intervention period. The comparison between groups revealed a statistically significant difference only in the daily use of midazolam, with a mean of 9.6 mg/day of stay in the control period vs 3.8 mg/day of stay in the test period (*P* = .019). Differences observed in other drugs—including dexmedetomidine, fentanyl, propofol, clorazepate dipotassium, diazepam, and antipsychotics such as quetiapine, haloperidol, or risperidone—were not statistically significant.

**Table 3** Use of sedatives, analgesics, and antipsychotics (Adjusted for the length of stay).

| Drug | Control period | Intervention period | *P* value |
|---|---|---|---|
| Dexmedetomidine (mcg/day) | 65.52 | 57.02 | .576 |
| Fentanyl (mg/day) | 0.33 | 0.02 | .120 |
| Propofol (mg/day) | 111.59 | 87.87 | .427 |
| Dipotassium clorazepate (mg/day) | 0.7 | 0.32 | .165 |
| Diazepam (mg/day) | 0.63 | 0.25 | .065 |
| Morphine (mg/day) | 1.65 | 1.24 | .271 |
| Lorazepam (mg/day) | 0.07 | 0.09 | .460 |
| Quetiapine (mg/day) | 1.12 | 0.45 | .091 |
| Haloperidol (mg/day) | 0.02 | 0.0 | .086 |
| Risperidone (mg/day) | 0.00018 | 0.00012 | .586 |
| Midazolam (mg/day) | 9.6 | 3.8 | .019 |

Isoflurane use was introduced progressively in the ICU beginning in the 2nd half of 2023. Because its use during the control period was minimal and cumulative dose data were not systematically recorded, it was not included in the comparative analysis of sedatives.

**Table 4** Multivariate analysis (Binary Logistic Regression; Outcome: Delirium).

| Variable | OR | 95%CI | *P* |
|---|---|---|---|
| Intervention period (vs control) | 0.65 | 0.40–1.07 | .089 |
| Age (per 10 years) | 1.11 | 0.90–1.36 | .32 |
| Male sex | 1.16 | 0.70–1.92 | .55 |
| APACHE II (per 5 points) | 1.09 | 0.88–1.36 | .38 |
| Emergency vs scheduled admission | 1.21 | 0.71–2.05 | .47 |
| Days on MV (per 10 days) | 1.04 | 0.93–1.17 | .39 |
| Midazolam $\geq$ 5 mg/day | 1.95 | 1.02–3.72 | .041 |
| Diazepam $\geq$ 0.5 mg/day | 1.34 | 0.77–2.42 | .28 |

In the multivariate analysis (Table 4), the intervention period was associated with a nonsignificant trend toward a lower incidence of delirium (OR, 0.65; 95%CI, 0.40–1.07; $P = .089$). In contrast, the use of midazolam $\geq$ 5 mg/day was identified as an independent risk factor (OR, 1.95; 95%CI, 1.02–3.72; $P = .041$). The remaining variables included in the model showed no significant associations. These results suggest that the observed reduction in agitation (RASS) during the intervention period may have facilitated decreased use of midazolam, which, in turn, may help explain the trend toward a lower incidence rate of delirium.

No adverse effects attributable to the multisensory intervention were identified.

## Discussion

Delirium remains one of the most prevalent neurological complications in critically ill patients, with well-documented consequences during hospitalization and after discharge. Its occurrence has been associated with increased mortality, longer ICU and hospital stays, and persistent cognitive impairment that can significantly affect quality of life and functional reintegration.[1,3,4,8] In this study, we evaluated the effect of a structured environmental intervention based on the simulation of circadian rhythm through a multisensory environment. A trend toward a lower incidence rate of delirium was observed in the intervention vs the control group (9.06% vs 14.34%), although without statistical significance ($P = .075$). This reduction is consistent with previous evidence linking sleep–wake disruption and circadian desynchronization to increased susceptibility to delirium in critically ill patients.[6,17] Moreover, the intervention was associated with a significant change in the agitation–sedation profile, as reflected in the redistribution of Richmond Agitation–Sedation Scale (RASS) scores. An increase in ''alert and calm'' (RASS 0) assessments and a reduction in moderate sedation and mild agitation were observed. These differences were statistically significant ($P < .001$). Extreme levels of sedation (deep) or agitation (moderate to severe) have been associated with worse clinical outcomes, including higher delirium incidence, prolonged mechanical ventilation, increased risk of adverse events, and worse overall functional recovery.[12]

Regarding the use of sedatives, a significant reduction in the mean daily dose of midazolam was noted during the intervention period. This finding is consistent with current recommendations discouraging the use of benzodiazepines[7] and favoring safer alternatives given their association with increased delirium risk, difficulty in ventilator weaning, and prolonged length of the ICU stay.[12] The use of fentanyl, quetiapine, and haloperidol showed a downward trend during the intervention period, though without statistical significance. This may be explained by the low overall consumption of these drugs and the wide variability in the sample, which limits statistical power. Nonetheless, the observed reduction is consistent with the RASS profile, which showed a lower degree of agitation. Overall, these findings suggest that the multisensory intervention may have contributed to decreased needs for opioids and antipsychotics, a hypothesis that warrants exploration in future studies with larger samples.

Of note, the study findings suggest that the multisensory intervention may reduce delirium incidence through various mechanisms. First, a lower level of agitation was noted during the intervention period according to RASS assessments. This pattern was associated with reduced midazolam use, which is consistent with the multivariate analysis in which doses $\geq$ 5 mg/day were independently associated with a higher risk of delirium. It is therefore plausible that decreased agitation facilitated reduced benzodiazepine exposure and, indirectly, a lower risk of delirium. Additionally, a direct effect of the multisensory environment on delirium prevention cannot be excluded, as it may reinforce circadian synchronization and improve the patients' temporal orientation. The two mechanisms—indirect via reduced midazolam use and direct via environmental modulation—are plausible and may have acted synergistically. These results underscore the need to further investigate environmental, nonpharmacologic interventions in delirium prevention in the ICU through controlled studies with larger sample sizes.

The study findings align with the comprehensive approach of the ABCDEF bundle, which promotes coordinated interventions to improve outcomes in critically ill patients. This model includes systematic delirium assessment, optimized analgesia, reduced sedation, early mobilization, sleep–wake cycle regulation, and active family engagement.[15] Its implementation has demonstrated efficacy in reducing the delirium incidence rate, the duration of mechanical ventilation, and the length of the ICU stay.[12,15] Of note, this study was conducted in an ICU with partial implementation of the ABCDEF bundle, with an intermediate level of adherence. Delirium and agitation–sedation monitoring, early mobilization, and family involvement were

routinely yet not uniformly applied across all patients or shifts. This context is relevant when interpreting the findings, as the multisensory intervention was integrated into a broader care strategy that had not yet achieved full ABCDEF implementation.

The physical ICU environment may play a significant role in disrupting biological rhythms. Factors such as continuous artificial lighting, high noise levels, fragmented sleep, and poor temporal orientation contribute to circadian dysregulation and cognitive instability.[6,13,18] In this context, nonpharmacologic strategies such as chronotherapy, controlled exposure to natural light, and dynamic circadian lighting have shown promising in supporting sleep–wake regulation and reducing the delirium incidence rate.[9,11,20] Furthermore, adding these environmental measures into ICU design aligns with modern humanization strategies, fostering a more comfortable, orienting environment for patients and their families.

This study has several limitations. As a nonrandomized quasi-experimental design, a causal relationship between the intervention and observed outcomes cannot be established. Moreover, the lack of blinding in data collection may have introduced bias, especially in clinically assessed variables. Although a reduction in the delirium incidence rate was observed, it did not reach statistical significance. It is possible that the sample size was insufficient to detect a difference of the observed magnitude or that the true effect is more modest than anticipated. Nonetheless, the 5.28% reduction could represent a clinically meaningful effect, meriting further evaluation in future studies with more robust designs and larger samples. On the other hand, sleep quality, functional trajectory, and cognitive outcomes after discharge were not collected,[5] limiting interpretation of the broader impact of the intervention. A potential seasonal effect on analgesia–sedation cannot be excluded; however, this was not part of the study objectives and was not specifically analyzed. Other limitations include the absence of systematic documentation of delirium subtype (hypoactive, hyperactive, mixed) and lack of stratified analysis by the length of ICU stay—both of which could have provided additional insight and represent paths for future research.

Of note, isoflurane use was not included in the sedative comparison because its implementation in our ICU began gradually in the 2nd half of 2023 and was minimal during the control period; moreover, cumulative dose data were not systematically recorded. This represents a limitation, particularly in units where inhaled sedation is fully implemented, as such agents must be included in comparative analyses, especially in pre–post or parallel-cohort designs.

Finally, being a single-center study, results must be interpreted within the context of the specific ICU environment and may not be directly generalizable to units with different characteristics or resources. Despite these limitations, the intervention demonstrated good feasibility and adaptability to clinical workflows. Compared with more complex technological strategies, the programmed system of light, images, and sound stands out for its accessibility, simple integration into routine care, and potential sustainability. Active engagement of the clinical team was essential for implementation—a factor to consider in future deployment strategies.

Overall, this study results suggest that implementing a multisensory environment synchronized with circadian rhythm is associated with a trend toward a lower proportion of patients with delirium, a significant redistribution in agitation–sedation levels, and reduced midazolam use. These findings reinforce the value of nonpharmacologic interventions as complementary strategies in the management of critically ill patients and highlight the need for prospective, controlled studies with larger sample sizes to confirm these effects and examine their impact on clinical, functional, and cognitive outcomes in ICU populations.

## CRediT authorship contribution statement

Francisco Esteve Urbano: Project coordination, Data analysis, Writing.
Gemma Vía Clavero: Data analysis, Writing.
Carlos González López: Coordination, Writing.
Paola Cárdenas Campos: Writing and review.
Herminia Torrado Santos: Writing and review.
Rosa María Granada Vicente: Writing and review.
Rafael Justel García: Coordination.

## Declaration of Generative AI and AI-assisted technologies in the writing process

Statement on generative AI and AI-assisted technologies in the writing process. During the preparation of this work, the author or authors used ChatGPT to improve the language and readability. After using this tool, the author or authors reviewed and edited the text and take full responsibility for the content of the publication.

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## Declaration of competing interest

None declared.

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