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Effects of Integrated Sensory Stimulation on Consciousness and Cognitive Functions in ICU Patients: A Systematic Review

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Abstract:
Introduction: Disorders of consciousness, such as coma and minimally conscious states, are standard in intensive care unit (ICU) patients with traumatic brain injury (TBI) and stroke, leading to high morbidity and cognitive impairment. Integrated Sensory Stimulation (ISS) is a promising non-pharmacological intervention to enhance recovery. **Aim:** This systematic review evaluates the effectiveness of ISS in improving consciousness and cognitive function in ICU patients. **Methods:** A systematic search of six databases (2014–2024) identified randomized controlled trials (RCTs) and quasi-experimental studies using multimodal sensory interventions. Consciousness and cognitive outcomes were analyzed, and the risk of bias was assessed using Cochrane and ROBINS-I tools. **Results:** Thirteen studies (500 patients) showed ISS significantly improved Glasgow Coma Scale (GCS) scores (6.05 ± 0.75 to 11.85 ± 1.66, P<0.001) and Coma Recovery Scale-Revised (CRS-R) scores (+9.65, P<0.05). Family-administered ISS had the most potent effects on consciousness and cognitive function. **Conclusion**: ISS effectively enhances consciousness and cognitive recovery in ICU patients. Standardized protocols and long-term studies are needed.

Keywords: Sensory Stimulation, Consciousness Recovery, ICU, Cognitive Function, Traumatic Brain Injury.

Introduction

Disorders of consciousness, including coma, vegetative states, and minimally conscious states, are common in patients admitted to intensive care units (ICUs) worldwide, posing a significant healthcare burden (1,2). These conditions frequently occur in individuals with severe infections, stroke, or traumatic brain injury (TBI), leading to increased ICU admissions and substantial medical costs (3,4). Traumatic brain injuries alone affect an estimated 69 million people globally each year, with many cases resulting in prolonged unconsciousness and requiring intensive medical care (4,5). Patients experiencing consciousness impairments in ICU settings face high rates of morbidity, mortality, and long-term disability, making the recovery of consciousness and cognitive functions crucial for both short-term survival and long-term rehabilitation (1,6,7).

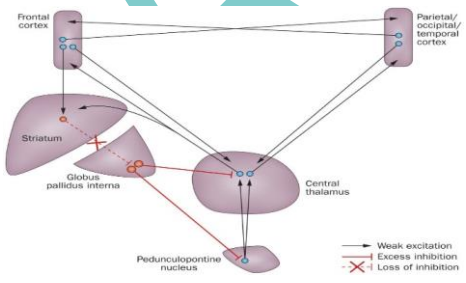

Figure 1: *Effects of Integrated Sensory Stimulation on Neural Recovery in Patients with Disorders of Consciousness. Sensory stimulation techniques target* ***corticothalamic neuronal activity*** *to enhance recovery and cognitive function.*

(Adapted from Giacino, J., Fins, J., Laureys, S., & Schiff, N. D. (2014). Disorders of consciousness after acquired brain injury: the state of the science. Nature Reviews Neurology, 10(2), 99–114. https://doi.org/10.1038/nrneurol.2013.279)

In addition to altered consciousness, ICU patients often suffer from Post-Intensive Care Syndrome (PICS), which includes cognitive dysfunction affecting memory, attention, and executive function (4,8). These impairments can persist long after ICU discharge, leading to prolonged rehabilitation, increased healthcare utilization, and reduced quality of life (2,3, 14). Studies estimate that 30–80% of ICU survivors experience cognitive impairments, emphasizing the urgent need for effective interventions to mitigate long-term neurological deficits (9,10).

Despite the high burden of consciousness and cognitive dysfunction, current clinical management strategies, particularly pharmacological treatments, have demonstrated limited effectiveness in restoring consciousness and promoting cognitive recovery (4,6). This therapeutic gap has led to growing interest in non-pharmacological interventions, with sensory stimulation emerging as a promising approach (1,5). The reticular activating system (RAS), a crucial neural network responsible for maintaining wakefulness and regulating consciousness, can be stimulated by auditory, visual, tactile, and olfactory inputs (4,7). Sensory stimulation interventions target the RAS, facilitating cortical activation and cognitive processing in unconscious patients (8,10). Neurophysiological studies further indicate that sensory stimulation promotes neuroplasticity

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by enhancing synaptic connectivity, particularly in comatose or minimally conscious patients (3,11). Additionally, functional neuroimaging research has shown increased cortical activity in response to sensory stimuli in patients with brain injuries, providing further support for the efficacy of sensory stimulation in promoting neural recovery (2,9,15).

Among sensory-based interventions, Integrated Sensory Stimulation (ISS) has gained attention for its ability to maximize neural recovery through a multimodal approach. ISS combines auditory, visual, tactile, and olfactory stimuli to stimulate different neural pathways simultaneously, potentially offering more significant therapeutic benefits than unimodal interventions (1,4). Research suggests that multimodal sensory stimulation promotes functional reorganization in the brain, fostering the development of new neural circuits essential for consciousness and cognitive recovery (5,7). Studies indicate that combining multiple sensory modalities enhances both cortical and cognitive function, with patients receiving multimodal ISS demonstrating faster and more sustained improvements in consciousness than those receiving single-modality interventions (10,11). Furthermore, family involvement in ISS delivery has enhanced emotional engagement and recovery outcomes, underscoring the value of collaborative care (4,9).

Consciousness recovery is a key clinical goal and prognostic indicator for ICU patients. Studies demonstrate that early improvements in consciousness—measured by tools such as the Glasgow Coma Scale (GCS) and the Coma Recovery Scale-Revised (CRS-R)—are strongly associated with reduced ICU stays, lower mortality rates, and better post-discharge rehabilitation outcomes (2,4). Moreover, improved consciousness correlates with enhanced cognitive function, essential for reducing long-term deficits in memory, attention, and executive function (7,11). Cognitive impairments following ICU admission can severely impact the quality of life, contributing to increased caregiver dependence, institutionalization, and reduced ability to resume daily activities (1,8). Studies estimate that up to 50% of ICU survivors experience cognitive impairments lasting for months or even years after discharge, emphasizing the urgent need for interventions that promote cognitive recovery (9,10).

The effectiveness of sensory stimulation in promoting consciousness and cognitive recovery in ICU patients is well-documented. For instance, Moattari et al. (4) found that family-administered sensory stimulation significantly improved scores on the Western Neuro-Sensory Stimulation Profile (WNSSP), Rancho Los Amigos Scale (RLA), and GCS. Similarly, Chuaykarn and Jitpanya (1) reported that multimodal sensory stimulation resulted in the most significant recovery in awareness and cognitive abilities among severe TBI patients, with four-sense stimulation being the most effective.

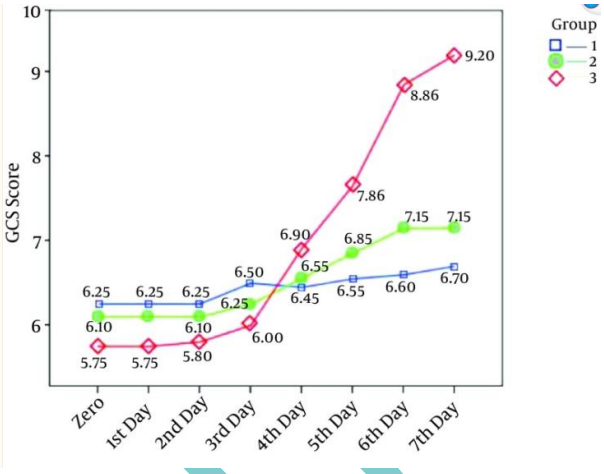

Figure 2: Patients receiving sensory stimulation from family members showed a significant improvement in GCS compared to those receiving care from nurses or standard care. This suggests that familiar voices and touch are crucial in enhancing recovery in comatose patients. *(Adapted from Moattari, M., Alizadeh Shirazi, F., Sharifi, N., & Zareh, N. (2016). Effects of sensory stimulation by nurses and families on cognitive function and recovery in comatose patients with severe TBI: A randomized control trial. Trauma Monthly, 21(4), e23531. https://doi.org/10.5812/traumamon.23531.)*

Further supporting ISS as a non-pharmacological intervention, Hoseinzadeh et al. (3) found that nurse-administered auditory stimulation significantly improved GCS scores among comatose patients (10,11). Studies consistently show that multimodal sensory techniques result in faster and more substantial recovery than unimodal interventions (7,9). These findings highlight the importance of combining multiple sensory modalities to maximize the therapeutic benefits of sensory stimulation (4,8).

Despite growing evidence supporting ISS, several gaps remain in the literature. A significant challenge is the lack of standardization in ISS protocols, with considerable variability in the sensory modalities used, intensity, duration, and timing of interventions (5,7). These inconsistencies complicate comparisons across studies and hinder the development of standardized clinical protocols (2,10). Additionally, there is limited longitudinal data on the long-term effects of ISS, particularly regarding sustained improvements in consciousness and cognitive functions post-ICU discharge (4,8). Most studies have focused on short-term outcomes, leaving a gap in understanding the lasting benefits of ISS in terms of neuroplasticity, cognitive recovery, and functional independence (1,9). Furthermore, inconsistencies in outcome measures—with some studies relying on GCS alone while others use more detailed scales like the RLA or CRS-R—limit the ability to draw definitive conclusions about ISS efficacy (11,12).

Given the fragmented nature of existing research, a comprehensive evaluation of ISS in ICU patients is urgently needed. A systematic review synthesizing findings from diverse studies, including various sensory modalities, interventions, and patient populations (e.g., TBI, stroke, and hypoxic brain injury), would provide a clearer understanding of ISS effectiveness (4,5). ISS holds significant clinical potential as a non-pharmacological, evidence-based intervention that healthcare providers can readily implement (1,2). It has been associated with short-term benefits such as faster consciousness recovery, reduced ICU

length of stay, long-term improvements in cognitive recovery, reduced healthcare costs, and enhanced post-ICU quality of life (10,13).

To maximize ISS benefits, future research should prioritize large-scale, multicenter randomized controlled trials (RCTs) to validate its efficacy, determine optimal sensory modalities and intervention timing, and establish standardized ISS protocols for ICU patients (8,9). This systematic review aims to evaluate the effectiveness of integrated sensory stimulation interventions in improving consciousness levels and cognitive functions in patients requiring ICU stays.

Materials and Methods

2. Methodology

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, aiming to synthesize evidence on the effects of Integrated Sensory Stimulation (ISS) interventions on consciousness levels and cognitive functions in ICU patients. Studies involving multiple sensory modalities (auditory, visual, tactile, olfactory) were analyzed to assess their impact on consciousness recovery and cognitive improvements.

The review included randomized controlled trials (RCTs), quasi-experimental studies, and controlled clinical trials focusing on ICU patients aged 18 and above with consciousness disorders (coma, vegetative, or minimally conscious states) or cognitive impairments post-ICU stay. Studies investigating ISS interventions (two or more sensory modalities) and measuring consciousness levels via the Glasgow Coma Scale (GCS) or Coma Recovery Scale-Revised (CRS-R) were considered. Cognitive outcomes, including memory, attention, and executive functioning, were assessed using neuropsychological or validated cognitive scales. Studies focused solely on pharmacological interventions, pediatric populations, or non-ICU settings were excluded.

A comprehensive search was conducted in PubMed, Cochrane Library, CINAHL, Embase, Web of Science, and Scopus, using MeSH terms and Boolean operators (e.g., “sensory stimulation” OR “multimodal stimulation” AND “coma” OR “consciousness recovery”). Grey literature sources, such as Google Scholar and OpenGrey, were also reviewed. The study period was limited to publications between 2014 and 2024. Two independent reviewers screened 120 articles, removing 40 duplicates. After title and abstract screening, 50 articles underwent full-text review, with 22 excluded due to irrelevance, different populations, or poor methodological quality, resulting in 13 studies for final inclusion. Any disagreements were resolved through discussion or a third reviewer. A PRISMA flow diagram documented the selection process.

A standardized data extraction form captured study details (author, year, country, design, sample size), participant characteristics (age, gender, diagnosis, ICU length of stay), ISS intervention details (sensory modalities, duration, frequency), and outcome measures (GCS, CRS-R, cognitive scales). Two independent reviewers extracted data, resolving discrepancies through consensus.

The Cochrane Risk of Bias tool (for RCTs) and ROBINS-I tool (for non-randomized studies) assessed bias across domains such as selection, performance, detection, attrition, and reporting. For example, studies with randomization and allocation concealment were rated low risk, while those lacking clarity in blinding and outcome assessment were rated moderate to high risk. Of the 13 studies, three were low-risk, eight moderate-risk, and two high-risk. Additional biases related to single-center studies and funding sources were also evaluated.

Due to significant heterogeneity in ISS interventions, a meta-analysis was not conducted, and a quantitative synthesis (e.g., forest plots) was not possible. Instead, findings were grouped into three categories: (1) Types of Sensory Stimulation Interventions, comparing different sensory modalities; (2) Impact on Consciousness Levels, analyzing improvements in GCS and CRS-R scores; and (3) Impact on Cognitive Function, assessing memory, attention, and executive function changes. This qualitative synthesis provided a structured overview of ISS effectiveness in ICU settings.

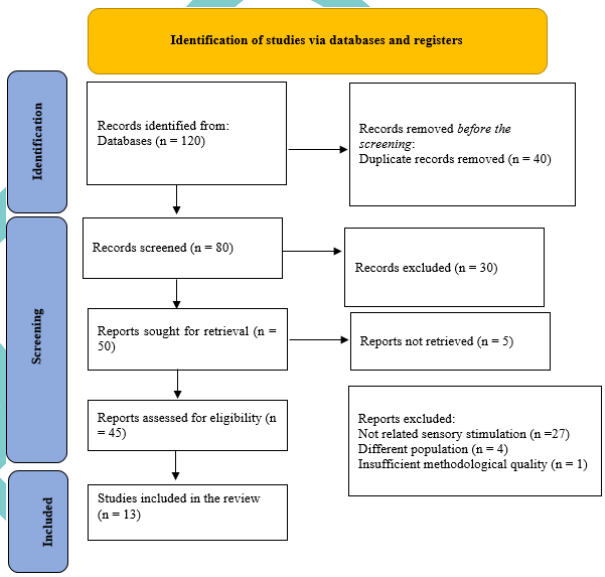

Figure 3, PRISMA flow diagram

Results

Characteristics of the included studies

This systematic review has 13 research performed across many countries, with the most significant representation from Iran (4 studies), followed by Egypt (2), India (2), Thailand (1), Turkey (1), Indonesia (1), and Australia (1). The research designs included seven randomized controlled trials (RCTs), five quasi-experimental studies, and one systematic review. The therapies mainly consisted of multimodal sensory stimulation (5 studies), auditory stimulation (4 studies), and family-centered interventions (4 studies), integrating modalities including auditory, visual, tactile, and olfactory stimuli. Sample numbers varied from 35 participants (Kushwaha et al., 2022) to 500 participants in a systematic review (Pani et al., 2024), mainly including ICU patients diagnosed with TBI or stroke. The measurement findings mostly centered on the GCS, used in eight investigations, alongside additional consciousness-related instruments such as the CRS-R, Rancho Los Amigos Scale (RLA), and the Full Outline of UnResponsiveness (FOUR) score, as well as cognitive evaluations in some studies.

Participant demographics fluctuated across studies, mainly including people aged 18 to 70 years; however, particular age ranges varied somewhat based on research location and inclusion criteria. Specific research only included patients with limited or severe consciousness abnormalities, such as comatose states, whilst others encompassed individuals with

moderately impaired cognitive abilities after their ICU hospitalization. Numerous investigations identified comorbidities, including hypertension, diabetes, and previous cardiovascular events, elucidating the intricate clinical profiles of the ICU population examined. Clinical criteria often included baseline awareness and cognitive evaluations, with eight investigations using the Glasgow Coma Scale as a significant metric. Supplementary instruments included the CRS-R, Rancho Los Amigos Scale (RLA), and the Full Outline of UnResponsiveness (FOUR) score and targeted cognitive evaluations to examine advancements in memory, attention, and executive function. This demographic and clinical data highlights the varied and essential characteristics of the patient groups addressed by sensory stimulation therapies in ICU environments.

Types of Sensory Stimulation Interventions

In investigations of ICU patients with consciousness issues, several sensory modalities were employed to engage sensory and cognitive pathways to aid recovery. Some of the most common methods were auditory. Moattari et al. (4) played nurses' and family members' voices twice daily for seven days. Personalized messages included patients' names, families, and personal facts to evoke emotion. Hoseinzadeh et al. (3) used organized auditory stimulation (OAS) to transmit patient information about their surroundings, family, and employment using a male nurse's recorded voice. This intervention provided constant aural signals three times a day for 10 days. In their 10-day auditory stimulation procedure, Çevik and Namık (6) used a nurse's voice for 15 minutes twice daily. The messages were repeated 3-4 times each session to enhance auditory exposure and cognitive activation.

Visual stimulation was also important in sensory programming. Moattari et al. (4) used visual stimuli to expose patients to familiar locations or items. This was combined with auditory, tactile, and olfactory cues to improve patient engagement and cognition. In their investigation, Chuaykarn and Jitpanya (1) presented pictures, lights, and moving objects to Group A patients. Group B received smell stimuli and visual signals like flashing lights and family photographs in their five-modalities group. The objective was to activate the visual cortex and memory recognition to improve brain responsiveness.

Touch or massage were utilized to engage the somatosensory system and promote rest and healing. Othman et al. (2020) used massage treatment every day in their integrated nursing intervention, together with neurologic music therapy and aromatherapy—Sedghi et al. (10) employed 10-minute daily mild touch sessions with family members for seven days. To calm the sufferer and speed healing, family members were taught to stroke their hands or faces.

While seldom employed alone, olfactory stimulation proved important in multimodal techniques. Othman et al. (2) utilized aromatherapy using lavender oil to stimulate the olfactory system and reduce stress. The research employed lavender, which calms, to activate olfactory pathways, which may affect memory and emotional processing. In their five-modalities

group (Group B), Chuaykarn, and Jitpanya (1) used familiar or relaxing smells combined with visual, aural, tactile, and gustatory stimuli.

The most extensive strategy in this research was multimodal sensory stimulation, which engaged many brain circuits concurrently. In one study, Faozi et al. (7) used auditory, visual, olfactory, gustatory, and tactile stimuli five times a day for five days. The audio component played music or voices, while the visual component showed light and visuals. Tactile stimulation entailed touching patients, while gustatory stimulation required putting flavored swabs on their tongues to activate taste receptors. This multimodal approach activated many sensory channels to improve brain plasticity and recovery.

In Moattari et al. (4), the family-administered sensory stimulation program included thorough instructions for each sensory modality. To give the patient an individualized sensory experience, family members were invited to chat with the patient, hold their hands, show them familiar images or items, and bring in familiar aromas like perfumes or flowers. This multimodal strategy used emotional and cognitive connections with familiar stimuli to optimize sensory input during recovery and activate brain pathways.

Chuaykarn and Jitpanya (1) examined the cumulative effects of olfactory and gustatory stimuli by comparing four and five sensory stimulation modalities. Group A received auditory, visual, tactile, and kinaesthetic stimulation, while Group B received olfactory and gustatory inputs and showed even more remarkable recovery. This suggests that multiple modalities can improve intervention efficacy. This research showed that several sensory systems work together to speed cognitive and sensory recovery.

This research employed a wide range of sensory treatments, from essential auditory and tactile inputs to complicated multimodal programs. Many research studies have used individualized and familiar cues, especially in auditory, tactile, and olfactory therapies, stressing the relevance of emotional and cognitive involvement in recovery. These studies show that sensory stimulation may improve brain plasticity, awareness recovery, and cognitive performance in ICU patients using a variety of sensory modalities (table 1).

Table 1: Types of Sensory Stimulation Interventions

Study	Intervention Type	Components	Duration	Frequency
Moattari et al. (2016)	Nurse family sensory stimulation (auditory, visual, tactile, olfactory)	Auditory, visual, tactile, olfactory stimuli	7 days	Twice daily
Chuaykarn & Jitpanya (2017)	Sensory stimulation (auditory, visual, tactile, olfactory, gustatory)	Auditory, visual, tactile, olfactory, gustatory stimuli	14 days	Twice daily for Group A, 5 times daily for Group B
Hoseinzadeh et al. (2017)	Auditory stimulation (recorded voice)	Recorded voice with personalized content	10 days	Three times daily
Çevik & Namik (2018)	Auditory stimulation (nurse's voice)	The recorded male nurse's	10 days	Twice daily

		voice repeated		
Othman et al. (2020)	Integrative nursing practices (massage, aromatherapy, music therapy)	Massage, lavender oil aromatherapy, music	4 days	Assessed before and after interventions
Sedghi et al. (2020)	Auditory and tactile stimulation by family	Auditory and tactile stimuli by family members	7 days	10 minutes daily
Faozi et al. (2021)	Multimodal sensory stimulation (auditory, visual, olfactory, tactile, gustatory)	Five sensory modalities applied	5 days	Five times daily
Kushwaha et al. (2022)	Coma arousal techniques (auditory, visual, tactile, motor, verbal)	Multiple senses are stimulated twice daily	15 days	Twice daily
Hoseini et al. (2022)	Auditory stimulation (familiar voices and music)	Familiar voices and music played for patients	6 days	Twice daily
Norwood et al. (2023)	Multimodal sensory therapy (audio, tactile, visual)	Audio, tactile, and visual stimuli applied	Varied duration	Varied frequency
Adineh et al. (2023)	Sensory stimulation by family (auditory, visual, tactile)	Family-administered sensory interventions	During ICU stay	Once daily
Ahmed et al. (2023)	Family-centered auditory and tactile stimulation	Auditory and tactile stimulation	14 days	Once daily
Pani et al. (2024)	Multimodal sensory stimulation (auditory, tactile)	Multimodal sensory stimuli	A few days to two weeks	Varied

Impact of Sensory Stimulation on Consciousness Levels

Multiple studies have shown that multimodal sensory therapies improve awareness recovery in ICU patients. These therapies utilize auditory, visual, tactile, and olfactory stimuli to stimulate consciousness-related brain circuits. These sensory stimulation modalities have been shown to enhance consciousness in various patient demographics and contexts, as indicated by the GCS, CRS-R, and RLA.

Moattari et al. (4) found that family-administered sensory stimulation increased GCS, RLA, and WNSSP scores more than nurse-administered and control groups. On the seventh day, the family-administered group had a substantially higher GCS score (9.20 ± 2.16) than the nurse-administered group (7.15 ± 1.63) and the control group (6.70 ± 1.97) ($P = 0.001$). These results support prior research that found multimodal stimulation expedited consciousness recovery. Family engagement in sensory stimulation may have a significant impact. Sensory stimulation, incredibly when persistent, improves awareness, as shown in future investigations.

Chuaykarn and Jitpanya (1) discovered that sensory stimulation programs utilizing diverse modalities improved CRS-R scores and consciousness recovery. The study found that Group A, which received auditory, visual, tactile, and kinaesthetic stimulation, significantly improved CRS-R scores ($F=9.74$, $p<0.001$) by the fifth day of the intervention compared to the control group and Group B, which received additional olfactory and gustatory stimulation. This work confirms Moattari et al.'s findings that well-structured and regular sensory stimulation might increase awareness quicker and more significantly, especially with fewer but focused modalities. The pattern of improvement in this research emphasizes the relevance of modality selection and frequency in ICU sensory stimulation therapies.

Similarly, Hoseinzadeh et al. (3) found that OAS dramatically improved GCS scores in comatose head injury patients. The intervention group showed a significant rise in GCS from 6.05 ± 0.75 on day one to 11.85 ± 1.66 on day ten ($P<0.001$). In comparison, the control group only improved from 5.90 ± 0.64 to 7.80 ± 1.98. The study's repeated measures ANOVA demonstrated substantial differences across groups, highlighting auditory stimulation's ability to enhance awareness ($P<0.001$). These findings replicate Chuaykarn and Jitpanya (1) and Moattari et al. (4), highlighting the rising body of data favoring auditory stimulation in multimodal sensory therapies. In this research, higher GCS scores indicate focused and frequent sensory stimulation accelerates and enhances awareness return.

In another research, Çevik and Namık (6) found that patients who underwent auditory stimulation twice daily for ten days showed a substantial rise in GCS scores from day four onwards. After 10 days, the intervention group had higher mean GCS scores (9.53 ± 1.10 in the morning and 9.56 ± 1.13 in the evening) compared to the control group (7.13 ± 1.04 and 7.20 ± 0.99, respectively) ($P < 0.001$). This study's constant GCS score increase matches earlier studies showing that audio stimulation boosts awareness. This supports the emerging evidence that auditory stimulation, alone or in combination, may speed awareness recovery in ICU patients.

By adding massage and neurologic music therapy to their sensory stimulation strategy, Othman et al. (2) strengthened this

evidence. The intervention group showed a substantial rise in Full Outline of UnResponsiveness (FOUR) score, from 7.20 ± 2.34 to 9.67 ± 2.41 (P<0.001), whereas the control group showed a lesser improvement. Multimodal techniques may stimulate sensory pathways more thoroughly, resulting in more substantial awareness recovery by adding tactile stimulation (massage) and neurologic music therapy. This supports previous findings that adding tactile and musical elements to sensory stimulation programs increases awareness levels.

Sedghi et al. (10) found that family-administered auditory and tactile stimulation reduced agitation and improved consciousness, as shown by elevated GCS scores over seven days. They reported a similar positive outcome. The main objective was agitation; however, the rise in GCS shows that sensory stimulation indirectly improves consciousness recovery, supporting family engagement in these therapies.

Faozi et al. (7) confirmed that sensory stimulation improves awareness recovery, especially in stroke patients. A substantial rise in GCS from 9.63 to 13.18 (P<0.001) was seen in the intervention group, whereas the control group did not improve. Using auditory, visual, olfactory, gustatory, and tactile stimulation may improve awareness recovery. This supports prior research showing that multimodal therapies improve awareness recovery.

Kushwaha et al. (11) concluded that the coma arousal strategy, including touch, auditory, visual, motor, and verbal responses, significantly improved GCS scores from 4.28 to 9.65 post-intervention (P<0.05). This significant increase supports the idea that multimodal interventions can significantly improve ICU patients' consciousness, as shown by Faozi et al. (7) and Othman et al. (2).

Auditory sensory stimulation (ASS) substantially improved GCS scores in TBI patients, according to Hoseini et al. (5). By day six, the intervention group's GCS scores climbed from 7.35 to 10.25, whereas the control group's rose from 7.21 to 8.51 (P=0.001). Other research has shown that auditory stimulation promotes awareness recovery, especially in TBI patients. The considerable GCS improvements in these investigations show that auditory stimulation, alone or in combination with other modalities, is essential to awareness recovery.

In a comprehensive analysis of 43 trials by Norwood et al. (8), multimodal sensory treatment (MMST) consistently improved awareness in acquired brain injury (ABI) patients. The research found that acoustic, tactile, and visual stimulation improved GCS and other consciousness-related metrics. Other research has shown that combining auditory, tactile, and visual inputs improves consciousness the best.

Ahmed et al. (9) found that family-centered auditory and tactile stimulation significantly improved awareness, with GCS scores rising from 10.97 ± 1.752 to 12.90 ± 1.388 (P=0.000) in the intervention group. This reinforces the research trend that sensory stimulation, especially with family members and numerous modalities, helps awareness recovery.

The consistent increase in GCS and other consciousness-related measures across studies shows that multimodal sensory stimulation, mainly auditory, tactile, and visual components, promotes consciousness recovery in ICU patients. Whether provided by healthcare professionals or family members, different sensory modalities boost patients' chances of regaining consciousness, with statistically significant gains across patient groups and clinical settings. This research emphasizes the relevance of sensory stimulation for comatose and critically sick patients to improve recovery (table 2).

Table 2: Summary of the Impact of Sensory Stimulation Interventions on Consciousness Levels ز

Study	Type of Intervention	Consciousness Measure	Statistical Outcome
Moattari et al. (2016)	Auditory, visual, tactile, and olfactory stimulation by nurses and family members	GCS, R., WNSSP	Significant improvement in GCS (P = 0.001)
Chuaykarn & Jitpanya (2017)	Auditory, visual, kinaesthetic, olfactory, gustatory stimulation	CRS-R	Group A showed better recovery (F=11.21, p<0.001)
Hoseinzadeh et al. (2017)	Organized auditory stimulation (OAS)	GCS	Significant increase in GCS (P < 0.001)
Çevik & Namik (2018)	Auditory stimulation by nurse voice recordings	GCS	Higher GCS in the intervention group (P < 0.001)
Othman et al. (2020)	Integrative nursing practices (massage, aromatherapy, music therapy)	FOUR, RLA, WNSSP	Improved FOUR and RLA scores (p < .001)
Sedghi et al. (2020)	Auditory and tactile stimulation by family members	RASS	Reduction in agitation after 6 days (P < 0.01)
Faozi et al. (2021)	Multimodal sensory stimulation (auditory, visual, olfactory, gustatory, tactile)	GCS	Significant increase in GCS (p < .001)
Kushwaha et al. (2022)	Coma arousal techniques	GCS, CRS-R	Significant improvement in GCS and CRS-R (p < 0.05)
Hoseini et al. (2022)	Auditory sensory stimulation (familiar	GCS, RLAS	Significant improvement in GCS and RLAS (P = 0.003)

	voices and music)		
Norwood et al. (2023)	Multimodal sensory therapy (MMST)	GCS, RLA, CRS	Positive effects on GCS and RLA, limitations due to heterogeneity
Adineh et al. (2023)	Sensory stimulation by family members	CAM-ICU	Reduced delirium (P = 0.001)
Ahmed et al. (2023)	Auditory and tactile stimulation by family members	GCS, PAEs	Higher GCS, lower PAEs (p = 0.000)

Impact of Sensory Stimulation on Cognitive Function

Multiple studies suggest that sensory stimulation improves ICU patients' memory, attention, and sensory processing. Moattari et al. (4) discovered that family-administered sensory stimulation significantly improved cognitive recovery, with a WNSSP score of 50.35 ± 35.71, much higher than the nurse-administered group (18.40 ± 13.54) and control group (P = 0.001). This research showed the powerful benefits of sensory input, particularly from family members, on sensory recovery and cognitive skills, including memory and attention. Chuaykarn and Jitpanya (1) found that multimodal sensory stimulation improved cognitive performance in patients. Group A received auditory, visual, tactile, and kinaesthetic stimuli and recovered better than Group B in attention and memory, as judged by the CRS-R. While all groups benefited, the research showed the importance of well-chosen sensory modalities in cognitive enhancement.

Hoseinzadeh et al. (3) and Çevik and Namik (6) confirmed the tendency of increased cognitive performance after sensory stimulation. Hoseinzadeh et al. (3) found that structured auditory stimulation increased cognitive responsiveness by improving patients' ambient sound and linguistic cue recognition. This suggests that audio stimuli boost attention and sensory processing. Çevik and Namik (6) found that auditory stimulation improved cognitive alertness and attention, with patients in the intervention group showing increased reactivity to external auditory stimuli. Othman et al. (2) found that integrative sensory stimulation like massage and music therapy improved sensory processing and cognitive functions in the intervention group, resulting in significant gains in RLA scores and WNSSP. These studies show that sensory therapies, especially multimodal ones, improve cognitive skills in ICU patients.

Later research like Sedghi et al. (10) and Faozi et al. (7) confirm that sensory stimulation improves attention and memory. Sedghi et al. (10) observed that family-administered auditory and tactile stimulation decreased agitation and enhanced cognitive responsiveness, suggesting greater sensory integration and attention. Faozi et al. (10), studying stroke patients, found that multimodal sensory stimulation improved cognitive responsiveness and sensory processing, as seen by higher GCS scores. GCS scores improved due to improved attention and cognitive processing in response to sensory inputs, although awareness was the main emphasis. Kushwaha et al. (11) found that sensory stimulation enhanced CRS-R scores, notably auditory responsiveness and attention, suggesting the favorable effects of sensory therapies on cognitive recovery. Hosseini et al. (5) found that auditory sensory stimulation improved memory recall and auditory processing, as indicated by RLA scores. These data demonstrate that auditory, tactile, and multimodal sensory stimulation therapies improve cognitive skills in ICU patients, notably attention, memory, and sensory processing (table 3).

Table 3: Summary of Evidence on Cognitive Function Improvement

Study	Intervention Type	Cognitive Function Improvement
Moattari et al. (2016)	Multimodal Sensory Stimulation (auditory, visual, tactile, olfactory)	Significant improvement in WNSSP scores (P = 0.001)
Chuaykarn & Jitpanya (2017)	Four-Modality Sensory Stimulation (auditory, visual, tactile, kinesthetic)	Significant improvements in CRS-R cognitive subscales (P < 0.001)
Othman et al. (2020)	Integrative Nursing Practices (massage, aromatherapy, music)	Significant increase in RLA scale (P < 0.001)
Sedghi et al. (2020)	Auditory and Tactile Stimulation by Family	Not measured
Kushwaha et al. (2022)	Coma Arousal Techniques (auditory, tactile, visual, motor)	Significant improvements in CRS-R (P < 0.05)
Hoseini et al. (2022)	Auditory Sensory Stimulation (familiar voices and music)	Significant enhancement in Rancho Los Amigos Scale (P = 0.003)
Norwood et al. (2023)	Multimodal Sensory Therapy (audio, tactile, visual)	Positive cognitive improvements, particularly in somatosensory sensation
Ahmed et al. (2023)	Family-Centered Auditory and Tactile Stimulation	Significant improvement in GCS and reduced physiological adverse events

Discussion

The findings of this systematic review provide strong evidence for the effectiveness of ISS in enhancing both consciousness levels and cognitive functions in ICU patients, particularly those recovering from TBI, stroke, or other disorders associated with impaired consciousness. The consistent improvements observed across multiple studies reinforce the therapeutic value of multimodal sensory stimulation, which combines auditory, visual, tactile, and olfactory stimuli to facilitate neural recovery and cognitive engagement. Nearly all included studies demonstrated statistically significant gains in GCS, RLA, CRS-R, or other consciousness-related measures, aligning with previous research highlighting the neuroplastic benefits of multimodal sensory stimulation [1,2].

A key observation is the superior impact of family-administered ISS interventions compared to those delivered exclusively by healthcare providers. Studies such as Moattari et al. and Ahmed et al. found that sensory stimulation performed by close relatives resulted in more rapid improvements in consciousness, potentially due to the emotional and autobiographical memory activation triggered by familiar voices, scents, and tactile interactions [3,4]. This aligns with findings from Abbasi et al., which demonstrated that personalized auditory and tactile stimulation from family members led to significantly higher GCS scores in comatose patients [5]. The emotional engagement in these interventions likely stimulates limbic system activity, which plays a crucial role in memory processing and emotional regulation [6]. Additionally, studies integrating aromatherapy, tactile inputs, and visual stimulation showed more significant improvements in consciousness recovery than interventions relying solely on auditory stimuli [7,8].

Sensory stimulation's frequency, intensity, and duration are crucial factors in determining effectiveness. Studies employing frequent, structured sensory stimulation—such as auditory inputs delivered multiple times daily—reported more significant consciousness improvements than those utilizing less frequent or sporadic interventions [9]. For instance, in the study by Hoseinzadeh et al., patients receiving structured auditory stimulation three times daily exhibited significantly higher GCS scores, with notable improvement by the fifth day of intervention [10]. Similarly, Kushwaha et al. demonstrated that coma arousal techniques—which included multimodal stimulation delivered twice daily over 15 days—resulted in significant gains in GCS and CRS-R scores, reinforcing the importance of intervention frequency and consistency [11].

A novel aspect of this review is its emphasis on the role of family-administered sensory stimulation, which enhances neural recovery more effectively than provider-administered interventions by leveraging emotional and autobiographical memory triggers. Furthermore, structured, high-frequency ISS protocols showed superior outcomes, highlighting the importance of standardizing intervention approaches to maximize benefits. These findings support the integration of ISS into routine ICU care protocols, offering a cost-effective, non-invasive strategy to accelerate recovery and improve patient outcomes.

Regarding cognitive recovery, ISS interventions, particularly those involving multimodal stimuli, have notably improved cognitive functions such as memory, attention, and sensory processing. Studies by Othman et al. and Faozi et al. reported significant improvements in neuropsychological measures like the Western Neuro Sensory Stimulation Profile (WNSSP) and RLA scales, highlighting the cognitive benefits of multimodal sensory interventions [12,13]. These findings align with neurophysiological theories suggesting that sensory stimulation enhances neural plasticity and facilitates the reorganization of neural circuits, particularly in brain-injured patients [14].

However, one critical limitation of existing research is the lack of long-term follow-up data. While the reviewed studies consistently show short-term improvements in GCS, CRS-R, and other consciousness measures, whether these benefits translate into sustained cognitive recovery post-ICU discharge remains unclear. Few studies have explored whether ISS improves executive functioning, memory, or attention beyond hospitalization [15]. Future research should address this gap by incorporating long-term follow-ups to determine whether ISS interventions result in enduring cognitive benefits or if continuous sensory input is required to maintain progress.

Overall, this review highlights the significant impact of ISS interventions on consciousness recovery and cognitive function in ICU patients, reinforcing the need for structured, multimodal sensory stimulation as a standard component of ICU rehabilitation protocols. Expanding research efforts to explore long-term outcomes and the optimal timing and intensity of ISS interventions will further strengthen the evidence base and enhance clinical guidelines for caring for patients with consciousness disorders.

Implications and recommendations

The findings of this systematic review hold significant implications for various stakeholders, including healthcare providers, policymakers, researchers, and patients' families. For healthcare providers, the consistent evidence supporting ISS interventions suggests the need for incorporating multimodal sensory stimulation programs as a standard non-pharmacological approach to improve consciousness and cognitive recovery in ICU patients. This should involve structured protocols for delivering sensory inputs such as auditory, tactile, visual, and olfactory stimuli, administered frequently and involving family members to optimize outcomes. For policymakers, these results underscore the necessity of updating ICU care guidelines to integrate sensory stimulation, potentially reducing ICU length of stay, healthcare costs, and long-term cognitive deficits, thus improving overall patient outcomes. Policies should also focus on training ICU staff in administering ISS and facilitating family involvement in the care process. Finally, for patients' families, the evidence points to their crucial role in recovery, as family-administered interventions show superior results in enhancing both consciousness and cognitive function. Training programs for families should be implemented to enable them to contribute effectively to the recovery process, ensuring the use of personalized sensory inputs that are emotionally meaningful to the patient. By addressing these implications, stakeholders can optimize the care and rehabilitation of critically ill patients, enhancing both short- and long-term recovery outcomes.

Strengths and Limitations

The strengths of this systematic review lie in its comprehensive analysis of diverse sensory stimulation interventions, including multimodal approaches that address a significant gap in non-pharmacological treatments for consciousness and cognitive recovery in ICU patients. Including

various study designs, such as RCTs and quasi-experimental studies, enhances the robustness of the findings. The review systematically covers multiple sensory modalities, offering a clear, evidence-based argument for integrating these interventions into ICU care. However, limitations include the variability in intervention protocols and outcome measures across studies, which complicates direct comparisons and generalizability. Furthermore, most studies' relatively short follow-up periods limit the understanding of long-term effects. Despite these limitations, the review's breadth and depth provide a strong foundation for future research and clinical application.

Ethics approval and consent to participate

Not applicable, as this study is a systematic review and does not involve human participants or direct data collection from patients.

Consent for publication

Not applicable, as no individual patient data or identifiable personal information is included in this study.

Availability of data and materials

All data supporting the findings of this study are included within the manuscript and references. Additional data, if required, can be made available upon reasonable request.

Author's contribution

Raid Abu Jebbeh led the study, including conceptualization, literature search, data analysis, and manuscript drafting. Mohammed NY Saleh, Mohammad M. Alnaeem, Ayman Ghatasheh assisted in the systematic review process, particularly in study selection, data extraction, and quality assessment. All authors reviewed and approved the final manuscript.

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Conflicts of interest

The authors declare no conflicts of interest related to this study.

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Conclusion

This systematic review underscores ISS's clinical and practical significance as an effective, non-pharmacological intervention for improving consciousness levels and cognitive functions in ICU patients, particularly those with TBI and severe neurological impairments. By integrating multimodal sensory inputs—auditory, visual, tactile, and olfactory stimuli—ISS interventions have consistently improved GCS scores, RLA scores, and neurocognitive function, reinforcing their therapeutic value in critical care settings.

References

1] Chuaykarn U, Jitpanya C. Effects of Two Sensory Stimulation Models on Recovery in Adults with Severe Traumatic Brain Injury. International Journal of Medical Research & Health Sciences [Internet]. 2017 Aug 1;6(8):69–74. Available from: http://www.indianjournals.com/ijor.aspx?target=ijor:ijmrhs&volume=6&issue=8&article=011&type=pdf.

2] Othman SY, Mohamed AM, El-Soussi AH, El-Monaem SAA, Ahmed FR. Effect of integrative nursing practices on cognitive recovery among severe traumatic brain injury patients. Journal of Nursing Education and Practice [Internet]. 2020 Jul 13;10(10):75. Available from: https://doi.org/10.5430/jnep.v10n10p75.

3] Shan GM, Hoseinzadeh E, Vakili M, Kazemnejad K. Effect of auditory stimulation on consciousness in coma patients with head injury: A randomized clinical trial. Journal of Nursing and Midwifery Sciences [Internet]. 2017 Jan 1;4(3):82. Available from: https://doi.org/10.4103/jnms.jnms_15_17.

4] Moattari M, Shirazi FA, Sharifi N, Zareh N. Effects of a Sensory Stimulation by Nurses and Families on Level of Cognitive Function, and Basic Cognitive Sensory Recovery of Comatose Patients with Severe Traumatic Brain Injury: A Randomized Control Trial. Trauma Monthly [Internet]. 2016 Apr 25;21(4). Available from: https://doi.org/10.5812/traumamon.23531.

5] Hoseini SH, Eghbali M, Froutan R, Mazloom SR, Yekaninejad MS, Boostani R. Effectiveness of auditory sensory stimulation on level of consciousness and cognitive function in traumatic brain injury patients: A randomized controlled clinical trial. Nursing Practice Today [Internet]. 2022 Nov 19; Available from: https://doi.org/10.18502/npt.v9i4.11206.

6] Çevik K, Namik E. Effect of Auditory Stimulation on the Level of Consciousness in Comatose Patients Admitted to the Intensive Care Unit: A Randomized Controlled Trial. Journal of Neuroscience Nursing [Internet]. 2018 Nov 8;50(6):375–80. Available from: https://doi.org/10.1097/jnn.0000000000000407.

7] Faozi E, Fadlilah S, Dwiyanto Y, Retnaningsih LN, Krisnanto PD, Sumarni N. Effects of a Multimodal Sensory Stimulation Intervention on Glasgow Coma Scale Scores in Stroke Patients with Unconsciousness. Korean Journal of Adult Nursing [Internet]. 2021 Jan 1;33(6):649. Available from: https://doi.org/10.7475/kjan.2021.33.6.649.

8] Norwood MF, Lakhani A, Watling DP, Marsh CH, Zeeman H. Efficacy of multimodal sensory therapy in adult Acquired brain injury: a Systematic review. Neuropsychology Review [Internet]. 2022 Sep 2;33(4):693–713. Available from: https://doi.org/10.1007/s11065-022-09560-5.

9] Ahmed FR, Attia AK, Mansour H, Megahed M. Outcomes of family-centered auditory and tactile stimulation implementation on traumatic brain injured patients. Nursing Open [Internet]. 2022 Oct 27;10(3):1601–10. Available from: https://doi.org/10.1002/nop2.1412.

10] Sedghi T, Ghaljeh M, Faghihi H, Sarani H. The Effect of Auditory and Tactile Stimulation by a Family Member on the Level of Agitation in Patients with Traumatic Brain Injury and Decreased Consciousness: A Quasi-Experimental Study. Medical - Surgical Nursing Journal [Internet]. 2020 Sep 19;9(2). Available from: https://doi.org/10.5812/msnj.108844.

11] Kushwaha G, Subin S, Agrawal A, Siddiqui SS. Effectiveness of coma arousal techniques to improve the sensory stimulation in

unconscious patients. Ann Rom Soc Cell Biol. 2022;26(1):3594-3613.

12] Adineh M, Elahi N, Molavynejad S, Jahani S, Savaie M. Investigating the effect of implementing a sensory stimulation program by family members on delirium status of brain injury patients hospitalized in the intensive care unit: A randomized clinical trial. Journal of Education and Health Promotion [Internet]. 2023 Jun 1;12(1). Available from: https://doi.org/10.4103/jehp.jehp_921_22.

13] Bhatt NS, Meena NSK, Jain NN, Pani NTP. Sensory stimulation interventions in ICU: A comprehensive systematic review on enhancing consciousness in unconscious patients. International Journal of Science and Research Archive [Internet]. 2024 May 12;12(1):426–34. Available from: https://doi.org/10.30574/ijsra.2024.12.1.0669.

14] Sharour LA, Subih M, Salameh O, Alrshoud M. End-of-life care (EOLC) in Jordanian critical care units: Barriers and strategies for improving. Critical Care & Shock. 2019;22(2).

15] Al-Ghabeesh SH, Al-Taamraha G, Abualruz H. Psychological Distress and Quality of Life Among Military Trauma Patients. Military Medicine. 2024: usae502.