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RESEARCH ARTICLE

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Outcomes of family-centred auditory and tactile stimulation implementation on traumatic brain injured patients

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Abstract

Aim: To determine the outcomes of Family-centred Auditory and Tactile Stimulation Implementation on Traumatic Brain Injured Patients in Egypt.

Background: Family engagement in the care of their relatives in the Intensive care units is limited due to patients' life-threatening conditions, in addition to the use of high technology in these settings. Auditory and tactile sensory stimulations are among the diverse sensory stimulations that have received more attention in brain injured patients than other senses as being considered safe, and effective measures.

Design: A Quasi-experimental design was used to test the hypotheses of this study.

Methods: A convenience sample of 60 adult patients suffering from Traumatic Brain Injury and admitted to the intensive care units of two University Hospitals in Egypt was included in the study. Patients were assigned into two equal groups: control and study groups (30 patients each). The auditory and tactile stimulations were provided by trained family members, once daily for 2 weeks for the study group. Whereas routine communication was provided by the family of traumatic brain injured patients in the ICU for the control group. Two tools were used for data collection; tool one, the "Glasgow Coma Scale" to assess patient's level of consciousness, and tool two the "Physiological Adverse Events Assessment" to monitor patients for the occurrence of physiological adverse events. Data collection: January to October 2019.

Results: The implementation of an organized auditory and tactile stimulation by trained family members is associated with highly statistically significant positive effects . Patients in the study group showed a higher mean of consciousness, lower incidence rate of physiological adverse events, and a lower mean duration of ICU stay.

Conclusions: Implementation of an organized auditory and tactile stimulation by trained family members enhanced the consciousness level of comatose Traumatic Brain Injured patients, decreased the occurrence of physiological adverse events, and ICU length of stay. Thus, it is recommended for use in the daily routine nursing care of comatose Traumatic Brain Injured patients.

Relevance to Clinical Practice: This study gives a deeper understanding of how family engagement in the care of their critically ill relative enhances their recovery and improve their level of consciousness.

KEYWORDS
auditory stimulation, Egypt, family-centred care, outcomes, tactile stimulation, traumatic brain injury

1 | INTRODUCTION

Traumatic brain injury (TBI) is a major cause of deaths and disabilities among patients worldwide (Stocker, 2019). In Egypt, the incidence of TBI is increasing, with a statistically significant rise in transport-related head injuries. The majority of TBIs are related to motor vehicle accidents. Moderate and severe TBI accounted for 17.2% of all TBI presentations, and often necessitate admission to the intensive care unit (ICU) (Mohamed et al., 2018). Following severe TBIs, survivors often demonstrate a period of unconsciousness characterized by an inability to experience and interact with the environment. Patients can stay months to years in disorders of consciousness such as coma, unresponsive wakefulness syndrome, or minimally conscious state (Stocker, 2019; Zhu et al., 2019).

A growing literature suggests that the recovery process in TBI is activated immediately after injury. Brain plasticity allows the brain to modify its organization and function. Enhancement of plasticity occurs through both endogenous factors, namely the release of nerve growth factor. In addition to, exogenous factors, as environmental or sensory stimulation. Sensory stimulation can improve neuronal organization; increasing dendritic branching and numbers of dendritic spines; stimulating the reticular activating system and increasing the level of cognitive function (Cheng et al., 2018).

Sensory stimulation of sufficient frequency, intensity and duration can hasten the process of post-TBI brain plasticity, promote brain regeneration, improve neurologic function, shorten the length of ICU stay, and alleviate anxiety. Auditory and tactile sensory stimulations are among the diverse sensory stimulations that has received more attention than other senses as being considered safe, and effective measures. In addition to being commonly used in various healthcare settings. As a consequence, these two senses can be used in all aspects of patient care and the response can be observed (Mitchell et al., 2017; Salmani et al., 2017).

It is well-known that family engagement in critically ill patients daily care helps in their recovery (Burns et al., 2018). In this respect, Kleinpell et al. (2019) pointed out in their study that providing stimulation to comatose patients by their most statistically significant person plays a crucial role in their improvement, and that the optimum effort exerted by members of healthcare providers is statistically significant if accompanied by caring and loving attitudes of their statistically significant ones. Despite its importance to patients and families, incorporation of family members into the provision of critical care is still limited in Egyptian ICUs.

What does this paper contribute to the wider global clinical community?

This paper highlights the importance of family-centred care as an essential aspect of care of critically ill patients. This paper also shed the light on the importance of sensory stimulation provided to patients who were in a comatose state by their family members to enhance their recovery. Moreover, providing auditory stimulation by familiar voice like family member surpasses the unfamiliar voice of nurses and has emotional significance to the patient, and can consequently improve his/her condition.

Given the situation of the low nurse to patient ratio (1:2) in Egyptian ICUs (Eltaybani et al., 2020), nurses may have no time to implement sensory stimulation techniques to comatose patients. Hence, using family members in sensory stimulation could be a good alternative. Family engagement is a vital aspect of sensory stimulation for comatose patients following TBI, but research is scarce so far in the Egyptian context. In Egypt, several studies have been investigating the effect of sensory stimulation on improving TBI patients' level of consciousness (Mohamed et al., 2018; Mohammed & Hassane, 2017). However, little is known about the effectiveness of family members as the source of sensory stimulation in patients following TBI (Zuo et al., 2021). Therefore, we conducted this study to assess the effect of Family-centred organized Auditory and Tactile stimulation on TBI patients' level of consciousness and Physiological Adverse Events. We hypothesized that critically ill patients following TBI who are subjected to an organized auditory and tactile stimulation by family members exhibit improved consciousness level, lower incidence of physiological adverse events, and shorter length of ICU stay than those who are not subjected.

2 | METHODS

2.1 | Design

A Quasi-experimental design was used to test the hypotheses of this study.

2.2 | Settings and participants

This study was conducted in five adult ICUs of two University hospitals in Alexandria, Egypt. These units receive patients with different disorders in acute stage of illnesses or severe injuries including TBI. Participants were divided into two groups. Group 1 includes a convenience sample of 60 adult critically ill patients. Patients with a history of impaired hearing; hearing deficits because of trauma; alcohol or drug addiction; bleeding or surgery in the temporal region; induced coma; quadriplegia; and patients dead or being transferred before day 14 were excluded. Patients were randomly assigned using toss of a coin into two equal groups of 30 each: group A (control group) and group B (study group) (Figure 1). Sample size was calculated based on power analysis using Epi Info 7 program (expected frequency 50% [because of the absence of a precise sensory impairment rate among patients with TBI in Egypt], accepted error 10% and confidence coefficient 95%). Eligible patients were hemodynamically stable (systolic blood pressure of 90 < 140 mmHg, heart rate of 60–100 beats/min, a respiratory rate of 12–24 cycles/min, a body temperature of 36.5–37.2°C, and O_2 saturation >90%), with a Glasgow Coma Scale score ranging from 7–12. Whereas group 2: includes 60 family members (1 family member/patient) 30 family members in each group: group A (control group) and group B (study group) selected based on being the closest family member to the patient who were visited the patient at least twice after ICU admission.

2.3 | Instruments

Two tools were used to collect data in this study, the Glasgow Coma Scale (GCS), and the Physiological Adverse Events (PAEs) assessment tool.

2.3.1 | The Glasgow Coma Scale

This scale was adopted from Teasdale and Jennett (1974) to assess the patient's level of consciousness. Tool reliability had been approved in previous studies (Mohammadi & Yeganeh, 2019). The scale is based on numerical value assigned to the assessment of three responses namely, eye opening response, verbal response, and motor response. The three responses consist of 15 items, each response was scored separately (Eye opening response score out of 4, Verbal response score out of 5, and Motor response score out of 6) and then totalled score out of 15 as follows:

Total score of responses ranges from 3–15, with score 3 indicating severe neurological deficits (deep coma) and score 15 representing no deficits (full conscious). GCS scores from 3–8 indicates poor cognitive recovery, scores from 9–12 indicates average cognitive recovery and scores from 13–15 indicates good cognitive recovery.

2.3.2 | The physiological adverse events assessment record

This record was developed by the researchers based on reviewing the related literature and used to assess the patients for the occurrence of PAEs. The tool was tested for reliability using Cronbach's Alpha test ($r = .827$) and established to be reliable. The record includes the physiological adverse events such as, increase or decrease in the following parameters: temperature (*T*), mean arterial pressure (MAP), heart rate (HR), respiratory rate (RR), Random blood sugar (RBS), and decrease in oxygen saturation (SpO_2). The physiological parameters were organized in a flow sheet to document patient's data value from the beginning to the end of the study. The assessment was done by one consistent evaluator (the second author). Before the second author, who are clinical instructor holding a master's degree in critical care nursing, started training the family members, their inter-ratter reliability among them was tested by the first author. The first author is a clinical nurse specialist who holds a doctorate in critical care nursing with a long experience in the clinical settings. She trained the first author about the organized auditory and tactile stimulation (Abbasi et al., 2009) and observed him while doing the skill. The inter-ratter reliability among them was 100%.

In addition to the socio-demographic and clinical data. Socio-demographic data such as age, sex, marital status, educational level, occupation. Whereas, the clinical data includes the current diagnosis, mechanism of injury, presence of comorbidities presence of accompanying injuries, type of management, administered medications, and ICU length of stay (LOS).

2.3.3 | Physiological adverse events

Bradypnea: (RR < 12 cycle/min)	Tachypnea (RR ≥ 35 cycle/min)
Tachycardia: (HR > 100 beats/min)	Bradycardia: (HR < 60 beats/min)
Hypertension: (SBP ≥ 140 mmHg, DBP ≥ 90 mmHg)	Hypotension: (SBP < 90 mmHg, DBP < 60 mmHg)
High MAP: (MAP > 110 mmHg)	Low MAP: (MAP < 70 mmHg)
Hyperthermia: (*T* ≥ 37.5°C)	Desaturation: (SPO_2 ≤ 90%)
Hyperglycaemia: (BGL ≥ 200 mg/dl)	Hypoglycaemia: (BGL < 70 mg/dl)

2.4 | Data collection process

Patients who met the inclusion criteria were randomly assigned into two equal groups: the control and the intervention groups. A pilot study was carried out on 10% of the study sample i.e. six patients (and were excluded from the sample size) to test the clarity and applicability of the research tools before conducting the study and no modifications were needed.

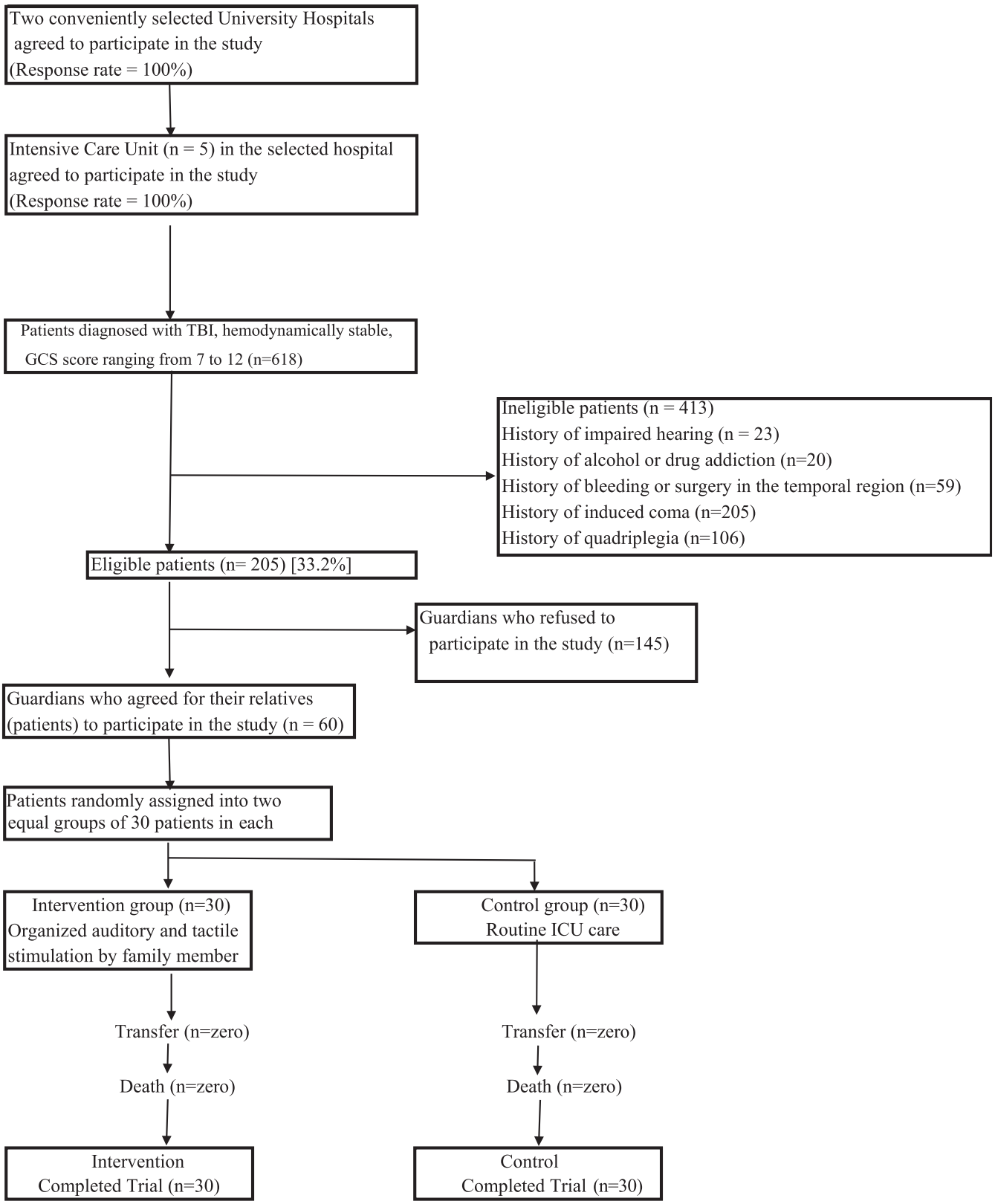

FIGURE 1 Sampling flowchart

Patients in the control group received the routine communications done by the family members regularly for ICU comatose patients following TBI such as shaking the hand, wiping the face, calling the patient by his/her name.

Whereas, patients in the intervention group were subjected to the organized auditory and tactile stimulation (Abbasi et al., 2009) whose program was considered well-organized, time- framed, and easily applied by family members in comparison with other programs

in addition to it was cited by other authors, which increase its generalizability. The intervention applied by a selected trained family member, which consists of three main phases as follows.

2.4.1 | Phase 1 (preparatory phase)

In this phase, the selected family member (the emotionally closest family member to the patient) received the necessary information by the second author using a demonstration approach on another volunteer family member and a power-point presentation about: the ICU equipment, the infection control precautions, signs of coma and the importance of the organized auditory and tactile stimulation they could provide to their comatose patients. Selected family members were trained on the provision of the organized auditory and tactile stimulation for two consecutive sessions immediately after patients' visiting hours for a duration of 15 min each session. After each session, the second author had observed their performance before proceeding to intervention implementation.

Before the stimulation intervention, the second author prepared the room as follows; curtains were drawn to provide privacy, and the surroundings were kept as quiet as possible, and the patient was kept in a resting position (semi-Fowler's position or appropriate position to the patient). Selected family member was asked firstly to disinfect his/her hands, wear gloves and sit on the chair beside the patient's bed, facing the patient to be in the auditory field.

2.4.2 | Phase 2 (implementation phase)

In this phase, the selected family member was invited in the presence of the second author to implement the organized auditory and tactile stimulation once daily during the visiting hours (2–3 p.m.) for 14 consecutive days or less if the patient discharged from ICU. Each session tool approximately 15 min divided into three sets of 5 min each as follows:

- In the first set of 5 min of the stimulation period, family member kept calm, touched the patient's hands gently, called and greet the patient by his/her name while maintaining one's normal tone of voice, introduced oneself, talked to the patient slowly about all the measures that had been done for the patient's improvement and the ongoing interventions, then wait for 1 min with silence and no touch.
- In the second set of 5 min, the family member touched the patient's head and face smoothly, oriented the patient with the current time and place, talked about household events and family members and waited again for 1 min with silence and no touch.
- In the third set of 5 min, the family member touched the patient's hands smoothly again, wished him/her good health, stated the time of the next visit, and finally said goodbye.

2.4.3 | Phase 3 (evaluation phase)

In this phase, the researchers documented patient's level consciousness (GCS) and PAEs for both groups twice; on admission to the ICU as a baseline data, and after the visiting hours on a daily basis.

Data collection took approximately 10 months from January to October 2019.

2.5 | Data analysis

The Statistical Package for Social Sciences (SPSS Version 20.0) was used for data analysis. Reliability of the tool was determined by Cronbach's alpha. Frequency tables and cross tabulations were used to illustrate the results of categorical data and tested by the Chi-squared test or the Fisher's exact test was used when 25% of the cells have expected count <5. Continuous variables were presented as mean ± *SD* (standard deviation). The two groups were compared with Student's *t*-test. For all used statistical tests, *p*-value equal or less than .05 was considered statistically significant, and if less than 0.001, it was considered a very highly statistically significant. *p*-Value was adjusted to accommodate the opportunity of a galloping alpha (Jafari & Ansari-Pour, 2019) using this equation $p_{\text{multiple}} = (1 - \alpha')\, m = 0.04$.

3 | RESULTS

A total of 60 patients following TBI participated in the study. The results of the Chi-squared test reflected no statistically significant differences between the two groups about socio-demographic and clinical data such as patients' age, gender, marital status, educational level, mean GCS score, CT scan findings, mechanism of injury, comorbidities, and type of management/medications ($p > .05$, Tables 1 and 2).

Furthermore, Table 2 showed no statistically significant differences between the intervention and control groups at the 1st day of study ($p = .470$). On the other hand, improvement in the mean score of GCS in the intervention group of patients was statistically significantly higher than the control group of patients at the 14th day of study ($p = .000$). Despite the two groups of patients were relatively similar at the start of the study, patients in the study group had a higher mean of GCS scores all over the study period after the application of family-centred organized auditory and tactile stimulation compared to the control group (Figure 2). Patients following TBI had variable improvements in their levels of consciousness, as illustrated in GCS results that 66.6% and 26.7% of patients in the control group had average and good recovery of consciousness, respectively, compared with 30% and 70% of patients in the intervention group at the last day of the study (Figure 3).

Table 3 revealed that the application of family-centred organized auditory and tactile stimulation has a positive effect on the physiological parameters of patients following TBI, as shown by the

TABLE 1 Distribution of TBI patients' socio-demographic and clinical data ($N = 60$)

Items	Intervention group *N* (%)		Control group *N* (%)		Test of sig	*p*
Age (years)						
18–<30	12	40.0	13	43.3	$X^2 = 0.599$	.897
30–<40	8	26.7	9	30.0		
40–<50	5	16.7	3	10.0		
50–60	5	16.7	5	16.7		
Gender						
Male	24	80	21	70	$X^2 = 0.000$	.626
Female	6	20	9	30		
Marital status						
Single	16	53.3	17	56.7		
Married	14	46.7	10	33.3	$X^2 = 3.697$	.296
Divorced	0	0	2	6.7		
Widow	0	0	1	3.3		
Educational level						
Illiterate	2	6.7	5	16.7		
Basic	10	33.3	6	20.0	$X^2 = 5.174$	.160
Intermediate	15	50.0	11	36.7		
University	3	10.0	8	26.7		
Occupation						
Unemployed/retired	9	30.0	10	33.3	$X^2 = 0.273$	.872
Employee	7	23.3	8	26.7		
Worker	14	46.7	12	40.0		
GCS score						
Mean ± *SD*	8.43 ± 0.935		8.27 ± 1.081		$t = 0.639$	.526
CT scan findings						
Subdural hematoma (SDH)	15	50	17	56.7	$X^2 = 0.268$	.398
Epidural hematoma (EDH)	6	20	4	13.3	$X^2 = 0.480$	.365
ICH and brain contusion	5	16.7	4	13.3	$X^2 = 0.131$	.500
Simultaneous SDH/EDH	2	6.7	3	10	$X^2 = 0.218$	.500
Others	18	60	16	53.3	$X^2 = 0.271$	.397
Mechanism of injury						
Motor vehicle accident	20	66.7	19	63.3		
Fall from height	8	26.7	7	23.3	$X^2 = 2.092$	.553
Assault	0	0	2	6.7		
Hard object hit the head	2	6.7	2	6.7		
Accompanying injuries						
Yes	25	83.3	22	73.3	$X^2 = 0.884$	.266
No	5	16.7	8	26.7		
Presence of comorbidities						
Cardiovascular	4	13.3	3	10.0		
Respiratory	3	10.0	4	13.3	$X^2 = 0.286$	.963
Endocrinal	3	10.0	3	10.0		
No comorbidities	20	66.7	20	66.7		

TABLE 1 (Continued)

Items	Intervention group N (%)		Control group N (%)		Test of sig	p
Types of management						
Medical	21	70	17	56.7	$X^2 = 1.148$	.211
Medical and surgical	9	30	13	43.3		
Administered medications						
Anaesthesia	1	3.3	0	0	$X^2 = 1.017$	.500
Analgesia	29	96.7	29	96.7	$X^2 = 1.017$	.500
Anticonvulsive	25	83.3	25	83.3	$X^2 = 2.963$	.097
Hyperosmolar	29	96.7	29	96.7	$X^2 = 0.000$	.754
Thromboprophylaxis	30	100	30	100	—	—
Vasopressor	11	36.7	13	43.3	$X^2 = 0.278$	.396
Others	25	83.3	29	96.7	$X^2 = 2.678$	.574

Note: χ^2 = Chi-squared test; t = Student t-test; p = p-value for comparing between the two studied groups.
Abbreviations: CT, computed tomography; GCS, Glasgow Coma Scale; ICH, intracerebral haemorrhage. Statistically significant at $p < .05$.

TABLE 2 Comparison of the mean level of consciousness among traumatic brain injured patients in the two groups

Level of consciousness	Intervention Mean ± SD	Control Mean ± SD	t	p
Pre-intervention (1st day)	8.31 ± 1.009	8.50 ± 1.119	−0.727	.470
Postintervention (14th day)	12.90 ± 1.388	10.97 ± 1.752	4.820	.000**

Note: t = Student t-test; p = p-value for comparing between the two studied groups.
**Statistically significant at $p \leq .05$.

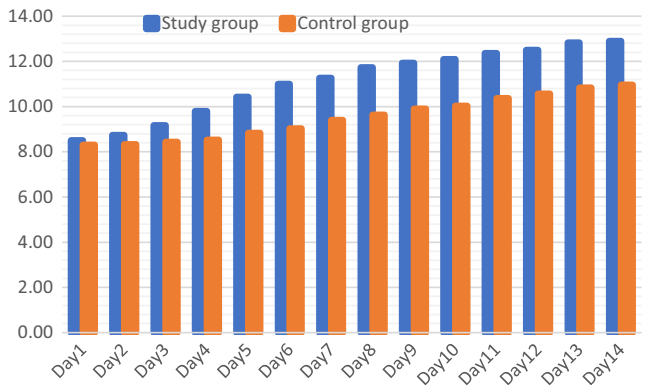

FIGURE 2 Change of GCS mean scores over the study period in the two groups

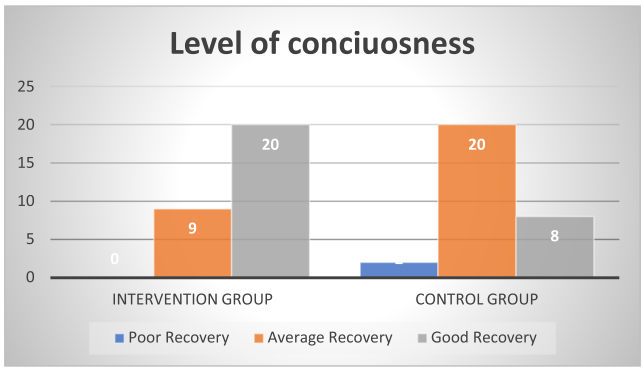

FIGURE 3 Level of consciousness recovery in patients following TBI in the two groups

statistically significant differences between the two groups in favour of the intervention group about heart rate ($p = .031$), respiratory rate ($p = .009$), MAP ($p = .039$), SPO_2 ($p = .000$), and random blood sugar ($p = .000$) by the end of the study. Findings of the current study supported that after 14 days of applying family-centred organized auditory and tactile stimulation, patients' level of consciousness in the intervention group statistically significantly improved and physiological adverse events statistically significantly decreased from the first to the fourteenth day.

Table 4 represents a comparison between the intervention and control groups about their ICU length of stay. The mean duration of ICU stay for patients in the intervention group was 19.77 ± 4.166 days compared to 26.37 ± 7.285 days for patients in the control group and the differences between the two groups were highly statistically significant ($p = .000$).

4 | DISCUSSION

Staying in ICU for long period with limited exposure to sensory stimuli increases the risk of sensory deprivation. Sensory deprivation can slow the recovery of central nervous function (Cheng et al., 2018). Considering the need for organized sensory stimulation in comatose

TABLE 3 Comparison of the mean physiological parameters adverse events in traumatic brain injured patients among the two groups

Evaluation items	Time	Intervention	Control	t	p
		Mean ± SD	Mean ± SD		
Temperature (°C)	Start	36.99 ± 0.193	36.96 ± 0.193	0.467	.642
	End	36.90 ± 0.158	36.84 ± 0.185	0.412	.432
Heart rate (beat/min)	Start	94.07 ± 3.383	95.17 ± 5.167	−0.976	.333
	End	84.97 ± 3.596	88.93 ± 9.150	−2.210	.031*
Respiratory rate (breath/min)	Start	25.90 ± 3.782	25.77 ± 3.830	−0.136	.893
	End	22.23 ± 3.501	25.37 ± 5.340	−2.688	.009*
Mean arterial pressure (mmHg)	Start	90.477 ± 3.439	90.480 ± 2.921	−1.011	.316
	End	88.155 ± 2.523	89.644 ± 3.010	−2.107	.039*
Peripheral oxygen saturation (SPO_2%)	Start	95.50 ± 2.162	95.23 ± 1.929	−3.340	.111
	End	97.62 ± 1.203	95.70 ± 2.176	6.093	.000**
Random blood sugar (mg/dl)	Start	131.43 ± 20.423	130.30 ± 13.020	1.003	.320
	End	106.17 ± 8.158	120.90 ± 18.687	−7.181	.000**

Note: *t* = Student *t*-test; *p* = *p*-value for comparing between the studied groups; Start = pre-intervention 1st day; End = postintervention 14th day.
*Statistically significant at adjusted $p \leq .04$.; **Highly statistically significant at $p < .01$.

TABLE 4 Comparison of the mean ICU length of stay in traumatic brain injured patients among the two groups

	Intervention	Control	t	p
	Mean ± SD	Mean ± SD		
Length of stay (days)	19.77 ± 4.166	26.37 ± 7.285	−4.308	.000**

Note: *t* = Student *t*-test; *p* = *p*-value for comparing between the studied groups.
**Highly statistically significant at $p < .01$.

TBI patients, it is much more effective if provided by a family member since this can change the patient's sensory stimulation to a meaningful content and promote patient's peace and comfort through making a supporting and familiar environment, and consequently hasten the improvement of patients' level of consciousness and disease prediction (Mohammadi & Yeganeh, 2019). Hence, the current study was implemented to assess the effects of Family-centred organized Auditory and Tactile stimulation on critically ill patients following TBI level of consciousness and Physiological Adverse Events. Findings of the current study supported the study hypotheses geared towards investigating the effectiveness of family-centred organized Auditory and Tactile stimulation in enhancing the traumatic brain injured critically ill patients' consciousness recovery and eliminating PAEs in 14 days of intervention. Given the homogeneity between the two groups of patients, statistically significant improvements in the intervention group can be attributed to the pure effect of Family-centred organized Auditory and Tactile stimulation.

According to brain plasticity and coma arousal theories, the brain's adaptive capacity to develop new pathways in the injured brain by passing the damaged part of the brain thus re-establishing a pathway to the healthy cells can be enhanced through the usage and increasing environmental stimulation. The affective stimulation by family members influences the brain and particularly activates the reticular activating system, resulting in increased norepinephrine release in nerve terminals, and greater consciousness and arousal (Cheng et al., 2018; Zhu et al., 2019). This may explain the statistically significant effect of Family-centred organized Auditory and Tactile stimulation on patients' level of consciousness in the intervention group.

It is notable that the LOC improvements started from the first day to the fourteenth days of the study for patients in the intervention group (Sedghi & Ghaljeh, 2020). Salmani et al. (2017) emphasized in their studies the pure effect of involving family members in the sensory stimulation, as explained by the statistically significant differences between the two groups of patients.

Findings of the current study indicated the absence of PAEs among patients in the intervention group compared with those in the control group, nearly in all physiological parameters namely, respiratory rate, heart rate, mean arterial pressure, SPO_2 and blood glucose level. In other words, findings of the current study reflected fluctuation between improvement and stability among patients in the intervention group compared with those in the control group along 14 days. Stability of these physiological parameters in the normal values may be explained by the balancing effects of auditory and tactile sensory stimulation by the family on both sympathetic and parasympathetic nervous system.

This is in line with Yekefallah et al. (2018) study findings, which concluded that the mean scores of heart rate, systolic and diastolic blood pressure, respiratory rate decreased statistically significantly in the study group compared with the control group, whereas the mean body temperature did not change in both study and control groups. Another study conducted by Yousefi et al. (2015) indicated that the SPO_2 was statistically significantly higher among agitated mechanically ventilated patients after implementing touch massage than in the control group.

This is in opposition to a study conducted by Khojeh et al. (2018) to investigate the effect of the organized auditory stimulation with a familiar voice on pain intensity and physiological indices of comatose patients admitted to ICU as they did not find statistically significant differences between the physiological indices including blood pressure, body temperature, and SPO_2 before and after the intervention. The reasons for that can be due to the different number of days, the nature of the voice played, and the duration of the intervention. In this respect, Mohammadi and Yeganeh (2019) also reported that their study of the effects of familiar voices on the level of consciousness among comatose patients indicated no statistically significant differences in hemodynamic parameters including blood pressure, body temperature, respiratory rate, heart rate and SPO_2 between the intervention and the control groups of patients. This could be attributed to the type of auditory stimulus and different sounds that can have different effects on patient. In addition to that, the patients in the cited study were in a more critical condition than the patients in the present study. Moreover, the differences may be attributed to the type of medications administered to these patients.

In terms of RBS, findings of the current study indicated a drop in patients' RBS level following the implementation of the family-centred organized auditory and tactile stimulation. The differences between the two groups were statistically significant with respect to the intervention group. This is congruent with a national research study finding carried out by Mohammed and Hassane (2017). Worldwide, however, there is limited research on the effect of sensory stimulation on RBS among patients following TBI.

Since patients' outcomes i.e., low incidence rate of PAEs and improved LOC in the intervention group of patients, were statistically significantly better than those in the control group, ICU nurses should advocate for family involvement in sensory stimulation for patients following TBI. Further studies are needed to investigate the feasibility of family-centred organized sensory stimulation in other healthcare systems and diverse cultures.

4.1 | Limitations of the study

This study was limited by the convenience nature of the sample, and the small sample size. Moreover, data were collected from four ICUs of a single hospital, which could hinder the generalizability of the study findings.

5 | CONCLUSION

Application of an early family-centred organized auditory and tactile stimulation is an effective and feasible nursing strategy in improving LOC among comatose patients following TBI in selected Egyptian ICUs. Moreover, a decreased incidence of PAEs was confirmed in the intervention group of traumatic brain injured patients. Further research studies are required to test the effect of other types of sensory stimulation among patients following TBI. It is recommended to integrate family-centred stimulation of critically ill comatose patients into undergraduate nursing curricula.

AUTHOR CONTRIBUTIONS

Fatma Refaat Ahmed involved in conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing the original draft review and editing, visualization and project administration. Amal Kadry Attia involved in conceptualization, methodology, software, validation, formal analysis, resources, data curation, writing the original draft, review and editing, visualization and supervision. Hamada Mansour involved in conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing the original draft, review and editing, visualization and project administration. Mohamed Megahed involved in conceptualization, methodology, software, validation, formal analysis, resources, data curation, writing the original draft, review and editing, visualization and supervision.

All authors have agreed on the final version and meet at least one of the following criteria [recommended by the ICMJE (http://www.icmje.org/recommendations/)]:

- substantial contributions to conception and design, acquisition of data or analysis and interpretation of data;
- drafting the article or revising it critically for important intellectual content.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICAL APPROVAL

Research Ethics Committee approval was obtained from the Faculty of Nursing—Alexandria University Ethical Committee. In addition to a written informed consent from the patient's guardian (people close the patient) and/or the selected family member (blood relatives) before participation in the study, and after explanation of the aim of the study, the potential benefits, risks, and discomfort from participation. Patients' privacy, and confidentiality of data were ascertained. Subjects were informed about their right to refuse to participate or withdraw from the study at any time.

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