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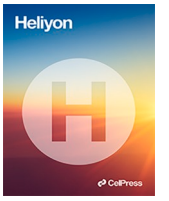

Review article

Post intensive care syndrome: A review of clinical symptoms, evaluation, intervention

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ABSTRACT

Post intensive care syndrome (PICS) is a typical complication of critically ill patients during or after their stay in intensive care unit (ICU), characterized by a high incidence and impairment rate. It significantly impacts the quality of life of patients and their families, as well as consumes a substantial amount of medical resources. Therefore, early intervention and assessment of PICS is crucial. This paper aims to provide clinical professionals with a reference base by focusing on the clinical symptoms, diagnostic assessment, and preventative measures of PICS.

1. Introduction

With the rapid development of modern medical technology, patients in ICU have obtained more advanced diagnostic, monitoring and treatment techniques, resulting in a significant upward trend in their survival rate [1,2]. However, studies have shown that survivors of ICU may be confronted with some symptoms of impaired physical, cognitive, mental, and/or social health that have long-lasting effects [3]. The Society of Critical Care Medicine (SCCM) referred to these symptoms as Post-Intensive Care Syndrome (PICS) during the Global Critical Care Conference in 2010 [4].

In recent years, the attention towards PICS has grown due to its impact on the prognosis of ICU survivors [5]. Studies have shown that more than 50 % of ICU survivors can concurrently experience one or more symptoms of PICS [6]. These symptoms include ongoing physical, mental, and cognitive impairments. Furthermore, it has been observed that even a year after being discharged, about 94.8 % of ICU survivors still attend general practice clinics [7]. Additionally, approximately 25 % of ICU survivors require assistance in daily activities, while 50 % are unable to return to their previous positions or work level, resulting in a loss of revenue [8]. In recent years, the growing elderly population has led to an increase in the number of patients in ICU, consequently raising the incidence of PICS [9]. Despite the increasing attention towards PICS and the emergence of guidelines advocating for early activity or sedation to mitigate its occurrence [10], there is currently no guideline that offers a comprehensive definition, clinical characteristics, diagnostic criteria, and treatment recommendations for this syndrome. Thus, it is necessary to review the research conducted on PICS in recent years to establish a reference basis for future studies and clinical works in this field.

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2. Definitions of post intensive care syndrome

PICS refers to the new or worsening impairments in one or more aspects of ICU survivors' physical, cognitive, mental and/or social health during treatment in ICU or transfer, which can continuously impact on their prognosis and quality of life (Fig. 1) [11]. Clinicians have observed that family members of ICU survivors are also at risk of developing post intensive care syndrome-family (PICS–F) [12]. In addition, pediatric ICU survivors experience symptoms of PICS, but their clinical manifestations vary due to their unique baseline status and different stages of growth and development. Recognizing this specificity, the Manning's research team proposed post intensive care syndrome-paediatric (PICS–P) in 2018, building upon the groundwork of PICS [13]. These conceptual frameworks outlined above enhance medical professionals' comprehension of PICS, facilitating its diagnosis and guiding interventions.

2.1. Post intensive care syndrome-paediatric

As a general term, PICS-P is a physical, cognitive, mental and/or social health issues that occur or worsened in critically ill children during or after treatment in paediatric intensive care unit (PICU) (Fig. 2) [14]. Physical impairment in PICU survivors after discharge is prevalent, ranging from 24 % to 35 %. Cognitive impairment rates may exceed 33 %, while the prevalence of depressive, anxious, and psychotic behaviors is approximately 40 %, 16 %, and 18 % respectively [15]. Additionally, a cohort study investigating the functional status of PICU survivors revealed that approximately 62 % of children displayed functional dysfunction upon discharge, with this impairment persisting in around 33 % of patients up to a year later. Notably, the study further highlighted that functional status at discharge was an independent risk factor for long-term functional outcomes, while age over 12 months was linked to better prognosis [16]. These symptoms can significantly impact the health-related quality of life of PICU survivors, hindering their recovery speed and effectiveness, and preventing them from returning to their baseline health status. Additionally, it has been suggested that factors such as the child's age, developmental stage, underlying diseases, life-saving therapy in PICU, and adjustments to the family's structure and functioning can influence the recovery trajectory of PICU survivors, resulting in unique recovery experiences for each individual [17].

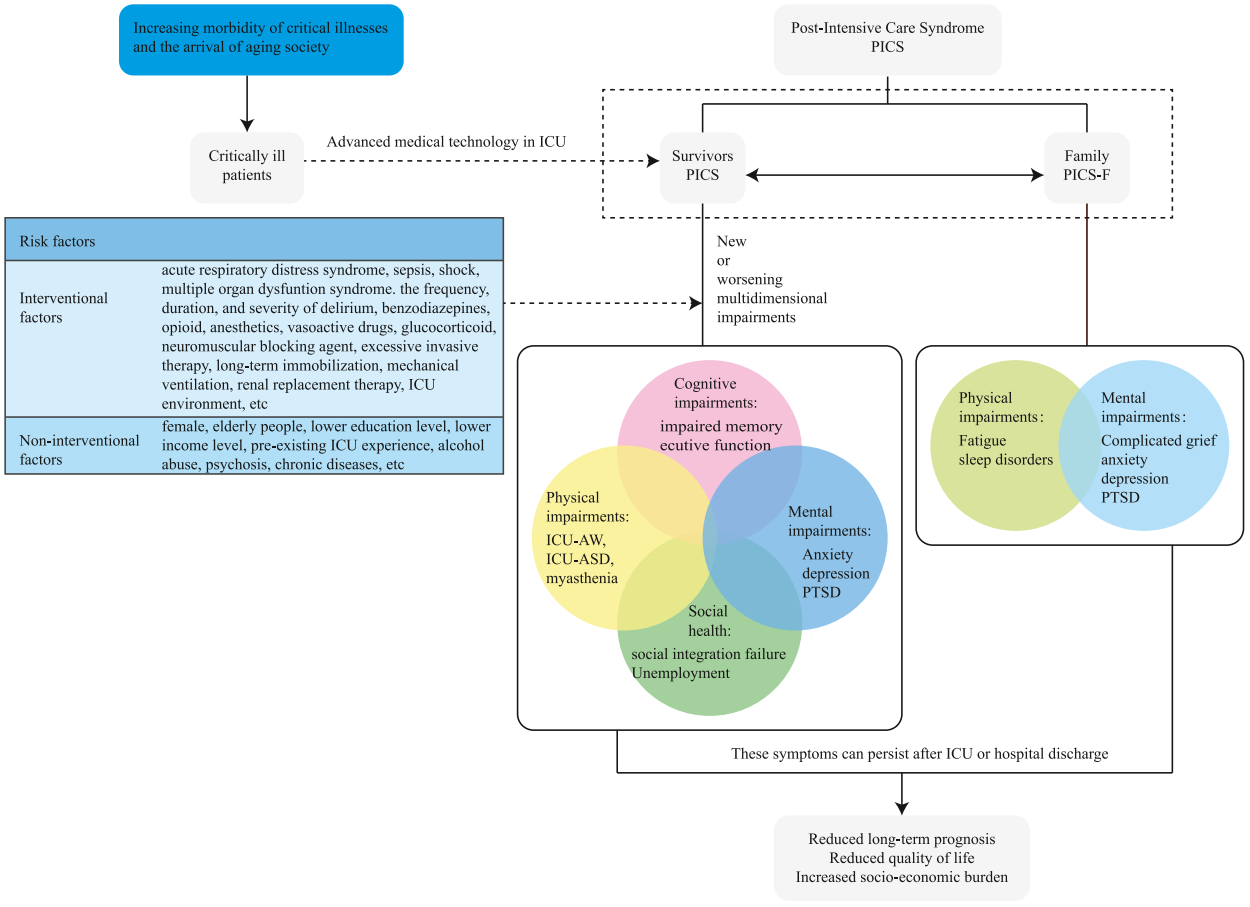

Fig. 1. Conceptual framework of post intensive care syndrome (PICS).

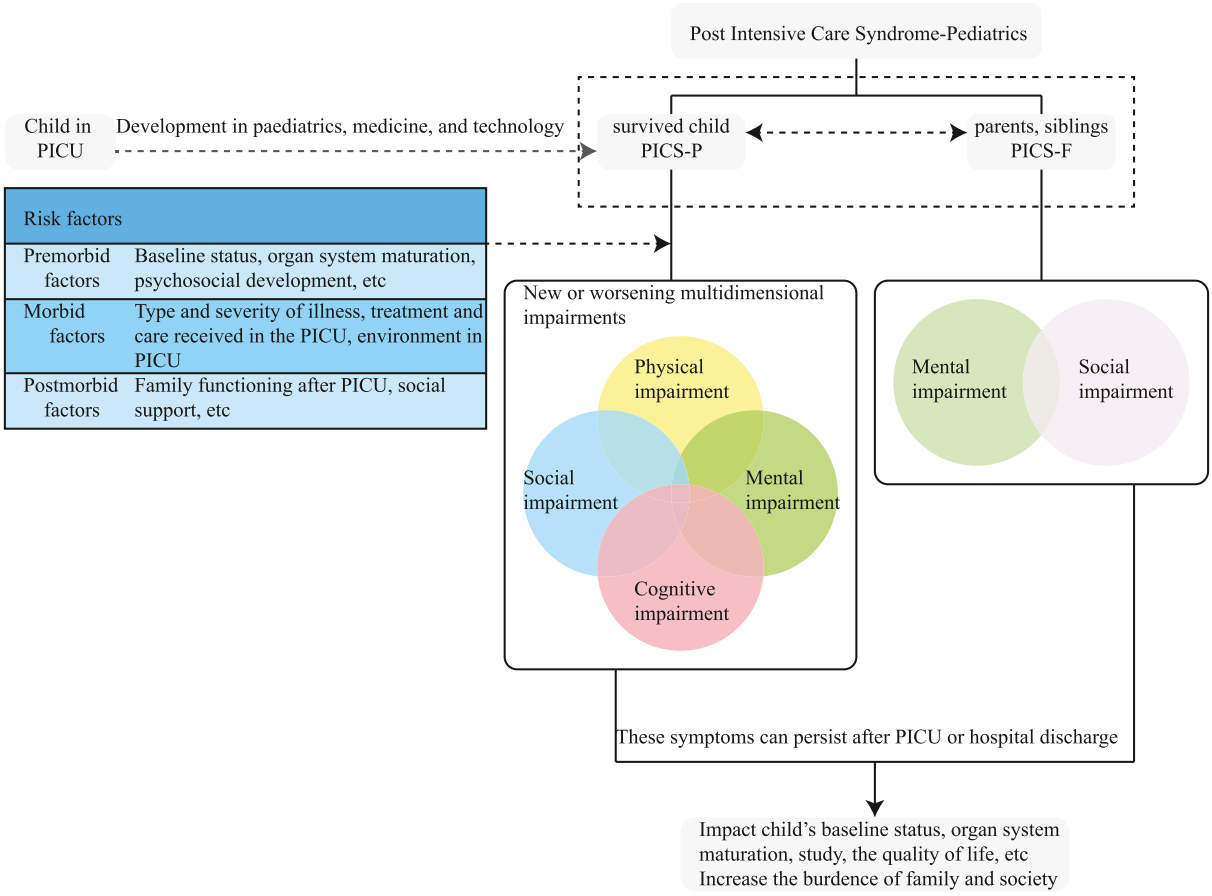

Fig. 2. Conceptual framework of post intensive care syndrome-paediatric (PICS–P).

2.2. Post intensive care syndrome-family

PICS-F is a physical and mental disorder whereby families of critically ill patients are confronted with the experience of ICU, required care and associated financial burdens [18]. These symptoms can have a long-lasting impact on the quality of life of the entire family. The primary physiological disorders observed in PICS-F patients are moderate to severe sleep disturbances and fatigue [19]. Insomnia is one of the earliest symptoms experienced by family members after critically ill patients have been admitted to ICU [20]. Even two months after ICU discharge, approximately 50 % of PICS-F patients continue to suffer from sleep disorders [18]. In terms of mental disorders, PICS-F patients commonly exhibit anxiety, depression, and post-traumatic stress disorder (PTSD) [21]. The persistence of psychological symptoms can exacerbate physical symptoms such as sleep disorders and fatigue, further diminishing health-related quality of life [19].

3. Risk factors

Numerous risk factors for PICS have been suggested, categorized as intervenable and non-intervenable based on their amenability to intervention. Intervenable factors are sub-categorized into disease and medical factors.

3.1. Intervenable factors

The patient's own illness conditions constitute crucial risk factors that encourage the emergence of PICS. Conditions such as acute respiratory distress syndrome, multiple organ failure, severe infections (such as sepsis and septicaemia), shock, and other ailments can cause hypoperfusion and hypoxia, resulting in permanent harm to the patients' brain function, nerves, blood vessels, and muscles [22]. These impairments lead to the physical, cognitive, and psychological anomalies experienced by PICS patients. A recent study suggests that severe sepsis plays a vital role in the development of chronic pain among PICS patients [23]. Additionally, the occurrence of cognitive impairment in PICS patients can be influenced by the frequency, duration, and severity of delirium during their stay in ICU

[24]. Therefore, enhancing the fundamental condition of ICU patients by promptly detecting and treating the underlying ailment can reduce the risk of PICS.

In addition to the severity and type of disease, specific treatments as well as the environment in ICU can contribute to the development of PICS. Scientific evidence suggests that certain drugs, such as opioids, benzodiazepines, anaesthetics, vasoactive drugs, and glucocorticoids, promote cognitive impairments in PICS patients [24]. Additionally, neuromuscular blocking agents and neurotoxic antimicrobial drugs can induce physiological dysfunction through neuromuscular dysfunction [25]. Furthermore, PICS can be influenced by excessive invasive therapy, long-term mechanical ventilation and immobilization, renal replacement therapy, and the noisy, bright and confined environment of ICU [26,27]. Therefore, to decrease the occurrence of post-ICU complications like PICS, it is important for clinical staffs to assess timely and accurately patients' conditions, understand proficiently drug indications, achieve therapeutic effects with the lowest possible doses, minimize invasive therapy without compromising patient recovery, and enhance the ICU environment.

3.2. Non-intervenable factors

The occurrence of PICS may be influenced by demographic and sociological factors, such as age, gender, personality, income, occupation, and education [6,24]. Additionally, pre-existing ICU experience, alcohol consumption history, mental illness history, and chronic illness history (eg. diabetes mellitus, hypertension) may also contribute to the emergence of PICS [28].

4. Clinical characteristics

4.1. Physical impairment

The main physical impairment of PICS patients are ICU acquired weakness (ICU-AW), ICU acquired swallowing disorder (ICU-ASD), muscle weakness, insomnia and so on. Additionally, they may present with fatigue, decreased bone mass, fragility fractures, reduced capability to perform daily activities, loss of appetite, endocrine metabolic disorders (including new-onset diabetes mellitus and temporary anterior pituitary hormone changes), and persistent chronic pain [3]. Among them, ICU-AW and ICU-ASD not only have a high prevalence [22,29], but also are associated with adverse clinical outcomes that include prolonged mechanical ventilation and hospital stays, an elevated risk of re-tracheal intubation and tracheotomy, decreased disease prognosis, and increased risk of patient death [30,31].

ICU-AW is a syndrome of limb weakness caused by neuromuscular dysfunction that arises without a clear etiology apart from the critical illness itself in critically ill patients during ICU stay or after discharge from ICU [32]. The dominant symptoms include diffuse, symmetrical generalised muscle weakness (primarily accumulation of the proximal limbs and diaphragm), decreased muscle tone, muscle atrophy, difficulty in extrication, diminished or normal reflexes, and mild paralysis or quadriplegia and so on. The American Thoracic Society classifies ICU-AW into three subcategories: critical illness polyneuropathy (CIP), critical illness myopathy (CIM), and critical illness myoneuropathy (CIMN) [33]. CIP is the most common type of ICU-AW, with an incidence rate of around 50 % [22]. ICU-ASD is the term used to describe the swallowing dysfunction that arise in critically ill patients during their stay in ICU, typically resulting from endotracheal intubation, central nervous system damage, tracheostomy, sensory abnormalities, and neuromuscular dysfunction, etc [34]. The most frequent form of ICU-ASD is Post Extubating Dysphagia (PED) [35].

4.2. Cognitive impairment

The clinical manifestations of cognitive impairment in PICS patients include long-term memory impairment, disorientation, inattention, new or worsened of delirium, confusion, impaired language function, decision-making, and executive ability. In severe cases, dementia of varying degrees can occur [36]. Memory, executive and decision-making abilities are the most frequently impaired by the aforementioned symptoms [37]. Fernández-Gonzalo et al. classified the typology of cognitive impairment in PICS into three phenotypes: K1, K2, and K3. The K1 phenotype significantly exhibits declining processing speed and executive ability. The K2 phenotype mainly manifests moderate to severe learning and memory deficits, as well as impaired processing speed and executive functioning. The K3 phenotype displays cognitive normalcy [37]. Notably, 13 % ICU survivors exhibited mainly K1 phenotype, and 37 % showed mainly K2 phenotype. Studies have revealed that cognitive impairment in ICU survivors can improve over time, but only a minority of patients recover to normal cognitive levels one year or more post-discharge [38,39]. Impaired cognitive function hinders the recovery process of ICU survivors, resulting in several detrimental outcomes, such as reduced independence, heightened financial burden for families, and increased long-term mortality rates [40,41].

4.3. Mental impairment

Depression, anxiety and PTSD are the most common mental impairment in PICS patients [42]. Due to their high comorbidity, these symptoms are typically diagnosed together rather than separately [43]. Anxiety symptoms commonly include irritability, apprehension, and fear, while depressive symptoms are characterized by emotional apathy, pessimism, and depression. On the other hand, PTSD symptoms involve the re-experiencing of trauma with hallucinations, illusions, or delusions dominating the experience after ICU. A British observational study, which followed 4943 ICU survivors for up to two years after discharge and assessed their psychological symptoms using the Hospital Anxiety and Depression Scale and the Posttraumatic Stress Disorder Examination Scale-Civilian Version

at three and twelve months after discharge, revealed that the prevalence of depression, anxiety, and PTSD were 40 %, 46 %, and 22 %, respectively [44]. These symptoms can persist in ICU survivors for a prolonged period, and their prevalence do not diminish over time [45], which can delay their recovery process, decrease the quality of life, and impede they from resuming work [44,46,47].

4.4. Failed social reconstruction

Failed social reconstruction is a social problem faced by ICU survivors after discharge for various reasons, including family instability, altered personal identity and perception, diminished interpersonal relationships, and unemployment [11]. ICU survivors tend to withdraw and reduce their independence when faced with the effects of physical, cognitive, and mental impairment, leading to the emergence of new or worsened social problems [48]. Additionally, 24 % of ICU survivors face unemployment even one year after discharge, resulting in new or worsened economic problems [49]. Therefore, it is crucial to prioritize the physical, cognitive, psychological, and social health problems of PICS patients and provide timely and suitable interventions and supportive measures to enhance their prognosis.

5. Evaluation

As a complex clinical syndrome, there is no definite diagnosis and treatment standard for PICS up to now. Hence, it is crucial to evaluate continuously and routinely the risk and severity of PICS [50]. However, the evaluation time, frequency, and tools of PICS are not unified due to its complexity. The SCCM proposed an ideal time for the early evaluation of PICS, which is 2–4 weeks after ICU survivors are transferred out of the ICU and when their health and quality of life have altered [51]. Many doctors in studies on PICS employ the evaluation time periods of three months, six months, and one year after ICU transfer of ICU survivors [6,52,53]. Additionally, a recent guideline on the rehabilitation of patients with PICS suggests that the assessment of PICS should be tailored to the stage of the disease, the patient's symptoms and risk factors, the environment, and the availability of further diagnostics [10].

5.1. Comprehensive assessment tools

Currently, there are few comprehensive assessment tools for PICS. Five available assessment tools are set of Outcome Measurement Instruments (OMI set), Provisional Questionnaire for Long-Term Health-Related Quality of Life and Burden of Disease after Intensive Care, Recovery After INtensive care (RAIN), Post-Intensive Care Syndrome Questionnaire (PICSQ), and Healthy Aging Brain Care Monitor (HABC-M) [54]. Among these, PICSQ and HABC-M are the more commonly used comprehensive assessment scales for PICS.

The PICSQ is a self-reported questionnaire developed by Korean scholar Jeong et al. in 2019, based on the PICS framework [55]. It consists of 18 entries, with 6 entries for each of its physical, cognitive, and mental aspects. The physiological aspect contains entries on functional diseases, reduced capacity to carry out daily tasks, and symptom experience. The cognitive aspect includes entries on memory and attention problems, impaired executive function, and abnormal visuospatial perception. The mental aspect covers entries on depression, anxiety, and PTSD. Each entry is graded from 0 to 3, and the total PICSQ score ranges from 0 to 54, with the higher score indicating more severe symptoms. The PICSQ is recommended for both clinical and scientific research to assess PICS because of its high reliability, convergent validity, and discriminant validity [56].

The HABC-M scale initially served as an assessment tool for physical, cognitive, and mental function in older patients in primary care [57]. Over time, it has been expanded into three versions: self-report, caregiver-report, and hybrid. All three versions have been validated for evaluating PICS [58]. Of these, the Healthy Aging Brain Care-Monitor Self Report (HABC-MSR) has been used to assess PICS in several countries due to its high internal consistency and reliability [59]. It contains 27 entries assessing the three dimensions of PICS (physical, cognitive, and mental) [57]. The physiological dimension consists of 11 entries, which focus on the ability to perform daily activities and quality of life. The cognitive dimension consists of 6 entries, which evaluate memory, judgement and decision making. The mental dimension consists of 10 entries that measure anxiety, depression, and PTSD. Each entry is scored on a scale of 0 (not at all) to 3 (almost every day), with a total score of 0–81. Similar to the PICSQ, higher scores on the HABC-MSR indicate more severe symptoms.

Table 1
PICS physical impairment evaluation tool.

Dimension	Evaluation tool
ICU-AW	Medical Research Council (MRC) [60], Neurophysiological examination [33], Neuromuscular biopsy [61], Biomarkers [62]
Ability of daily living	Barthel Index (BI) [63], Functional Independence Measurement (FIM) [60], Activities of Daily Living (ADL) [26]
Quality of life	Shot Form 36 Health Survey Questionnaire (SF-36) [64], European Quality of Life 5-Dimensions (EQ-5D) [51], European Quality of Life-Six Dimensions Self-classifier (EQ-6D) [65]
Fatigue	Fatigue Assessment Instrument (FAI) [66], the Multidimensional Fatigue Inventory (MFI) [54]
Sleep quality	Pittsburgh Sleep Quality Index (PSQI) [67]

PICS, post intensive care syndrome; ICU, intensive care unit; ICU-AW, ICU acquired weakness.

5.2. Single dimension evaluation tool

5.2.1. Physiological function evaluation scale

The evaluation of physiological impairments is currently primarily based on indicators such as ICU-AW, ability of daily living, quality of life, fatigue, and sleep quality (Table 1 displays the tools used for this purpose). The Medical Research Council (MRC), Barthel Index rating scale (Barthel Index, BI), and European Quality of Life 5-Dimensions (EQ-5D) are commonly evaluation tools for physiological impairments in PICS-related studies. These tools are used to assess ICU-AW, ability of daily living, and quality of life, respectively.

The MRC was initially used primarily to assess muscle strength in patients with peripheral nerve injury [68]. However, it is now widely used in the diagnosis of ICU-AW because of its cost-effectiveness, ease of administration, and non-invasiveness [33]. In the diagnosis of ICU-AW, the MRC scoring criteria are combined with the joint muscle groups of the upper and lower limbs. Each joint muscle is scored on a scale of 0–5, and the total score ranges from 0 to 60. The diagnosis of ICU-AW is made when the total score is less than 48 or the mean MRC score is less than 4 [32].

The Barthel Index (BI) is a scale that is frequently employed to evaluate the ability of performing daily activities for PICS patients [69]. Comprising 10 activities, including eating, bathing, dressing, walking on level ground and so on, this scale measures a patient's independence in completing these tasks [69]. Each item is scored according to specific criteria, and the total score is the sum of all item scores. The range of scores is from 0 (indicating complete inability to complete tasks independently) to 100 (indicating complete independence). A lower score indicates a greater degree of disability and the need for more nursing care assistance [70].

The EQ-5D is a widely used tool for evaluating the quality of life of ICU survivors [53]. The scale mainly consists of a descriptive system and a visual analogue scale. The descriptive system includes five dimensions: mobility, self-care, daily activities, pain or discomfort, and anxiety or depression. Each dimension has three levels: no difficulty, some difficulty, and extreme difficulty. The visual analogue scale allows patients to assess their general health by assigning a score ranging from 0 (worst health) to 100 (best health). Currently, the scale has been translated into several versions [71]. The Chinese version has passed Chineseisation and reliability tests and is widely used in China [72].

5.2.2. Cognitive function evaluation scale

Currently, there is no consistent recommendation for the optimal evaluation tool for cognitive impairment in PICS patients at home and abroad. The widely utilized evaluation tool include the Mini-Mental State Examination (MMSE) [73], the Montreal Cognitive Assessment (MoCA) [74], and the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) [75]. The MMSE, which is currently the most widely used tool for screening cognitive disorders [76], consists of six main domains: orientation, discrimination, memory, repetition and language, attention and calculation. It has a total score of 30 points, with scores below 24 indicating cognitive impairment. The MoCA was developed by the Neurological Research Centre of Chharles LeMoyne Hospital in Canada based on the MMSE scale developed by Folstein et al. [74]. It consists of 8 dimensions and 11 tasks, with a total score of 30 points. A cut-off score of 26 points is used if the individual has less than 12 years of education. Compared to the MMSE, the MoCA is better at screening mild cognitive impairment due to its absence of a ceiling effect, higher sensitivity, good internal consistency and re-test reliability, high feasibility, among other factors [77–80]. The RBANS is a sensitive tool for evaluating cognitive function [81]. It consists of five main dimensions: immediate memory, verbal functioning, attention, visual breadth, and delayed memory. Each dimension includes two to four items, resulting in a total of 12 test items. The total score is calculated as the sum of the 12 items, and lower scores indicate poorer cognitive function. It has been used to assess cognitive dysfunction symptoms in adults with PICS [75].

5.2.3. Mental function evaluation scale

The Hospital Anxiety and Depression Scale (HADS) is currently the primary scale utilized for the evaluation of mental function in PICS investigations [82,83]. The scale is primarily divided into two parts, anxiety and depression, each of which has seven entries with a range of 0–3 points [84]. The total score ranges from 0 to 42 points; with >8 points being considered positive, the higher the score, the more accurately it reflects the patient's level of anxiety and depression. Since the HADS does not assess PTSD, PTSD should be assessed separately. Currently, the tools used to assess PTSD symptoms in patients with PICS are the Impact of Event Scale-Revised (IES-R), the PTSD Checklist-Civilian (PCL-C), the Post-Traumatic Stress Symptom 10-Questions Inventory (PTSS-10), the Davidson Trauma Scale (DTS), etc [54]. Among these tools, the IES-R is the most frequently used scale to evaluate PTSD symptoms in PICS patients [85]. The scale covers three dimensions of avoidance, aggression, and high arousal, with 22 items. It is scored on a 5-point scale, with 0 denoting no effect and 4 denoting severe effect. It is generally agreed that a score of >26 denotes the existence of PTSD symptoms.

6. Intervention

6.1. Interventions during ICU

6.1.1. The ABCDEFGH bundle: Proposed at the second conference on PICS in 2012, the ABCDEFGH bundle is a comprehensive nurse-led and patient-centered interprofessional management strategy aimed at optimizing patient recovery [86]. It consists of the following components: A: assessment, prevention, and management of pain. B: Spontaneous Awakening Trials and Spontaneous Breathing Trials. C: Choice of Sedation and Analgesia. D: Delirium Assessment, Prevention, and Management. E: Early Mobility. F: Family Engagement, Follow-up Referrals, and Functional Reconciliation. G: Handover Communication. H: mission materials on PICS

and PICS-F [25]. A retrospective study demonstrated that this strategy reduces the risk of PICS by optimizing pain management, avoiding deep sedation, reducing the incidence of delirium, shortening the duration of mechanical ventilation, and facilitating the involvement of critically ill patients and their family members [87]. Additionally, Pun et al. conducted a prospective study with over 1500 adult patients in ICU, showing that adopting interventions based on the ABCDEF bundle during the early phase of treatment increases the survival rate of critically ill patients and further reduces the risk of post-ICU complications, such as PICS and readmission [88].

6.1.2. Supportive interventions: (1) Early mental support: It is vital in the context of critically ill patients admitted to the ICU. Upon admission, patients often experience mental symptoms such as agitation, irritability, and depression, which can be attributed to their lack of familiarity with the ICU environment and the associated fear it entails [89]. Research indicates that timely assessment of the mental state of ICU patients, combined with psychological treatments like psychoeducation, music therapy, and access to electronic devices like phones and laptops, has the potential to prevent and reduce psychological distress such as anxiety, depression, guilt, and social isolation [90]. These interventions are essential as they not only minimize these symptoms but also decrease the likelihood of developing PICS in ICU survivors. (2) Nutritional support: Malnutrition is a common issue in critically ill patients. Due to high catabolism and decreased protein synthesis, the majority of them experience impaired nutritional intake and absorption, leading to malnutrition. This is problematic as malnutrition has been linked to detrimental clinical outcomes, including increased incidence of physiological dysfunction, extended hospital stays, and higher post-discharge mortality rates [91]. To address this, the most recent clinical nutrition guidelines for the ICU recommend early nutritional support for all patients upon admission [92]. Implementing early nutritional support has been shown to improve clinical outcomes for ICU patients and decrease the incidence of PICS. (3) Improving the ICU environment: The ICU environment can have a significant impact on patients' recovery. The high levels of noise and constant bright environment in the ICU can lead to complications such as insomnia, irritability, and delirium, which can in turn increase the occurrence of post-ICU complications, including PICS [93]. Therefore, it is crucial to improve the ICU environment to reduce sensory overload and provide a conducive recovery environment. Studies have demonstrated that implementing noise reduction measures, such as optimizing the design of ICU buildings, utilizing noise reduction technology, and increasing noise reduction awareness among medical staff, along with light interventions such as lowering nighttime lighting and increasing daytime natural lighting, can effectively improve the ICU environment [94]. These measures alleviate patients' experience of pain, anxiety, and agitation, as well as reduce the incidences of sleep disorders and delirium, ultimately reducing the risk of PICS. (4) Other supportive interventions: There are other supportive interventions that have a positive impact on the psychological well-being of ICU patients and can decrease the incidence of depression, anxiety, and PTSD in patients experiencing PICS. Virtual reality technology [95], narrative care [96], music therapy [97], positive thinking therapy [98], and behavioral cognitive therapy [99] have all shown to be effective in this regard.

6.1.1. ICU diary

During treatment, ICU patients suffering from memory impairments can experience painful memories, recurrent hallucinations, nightmare delusions, and other mental symptoms. These symptoms can contribute to the development of PICS to a certain extent. To address this issue, scholars have found that the use of ICU diaries can be beneficial [100]. ICU diaries, which are distinct from ordinary diaries, are typically written by ICU medical workers or the patients' family members. They contain information about the patient's admission to the ICU, treatment process, changes in their condition, and visits by family members [101]. According to a meta-analysis, ICU diaries aid in the reproduction and reconstruction of patients' memories, promote a sense of well-being, alleviate psychological symptoms such as anxiety, depression, and PTSD, and improve their quality of life [102]. However, a recent clinical study revealed that while ICU diaries significantly reduce depression and anxiety levels in ICU survivors, their effectiveness in reducing PTSD symptoms is relatively poor [103]. This discrepancy may be attributed to differences in follow-up times and assessment tools used in these studies.

6.2. Interventions during ICU transitions

In 2005, Australian Chaboyer and other scholars proposed the ICU Transitional Care Model (ICUTCM) as a solution to the challenges faced by ICU survivors after being transferred from the ICU to the general ward [104]. The ICUTCM refers to the care provided by ICU nurses and other medical workers for critically ill patients throughout the whole process of care for ICU patients before, during, and after transfer. ICU survivors require high-quality care, but the general ward is ill-equipped and lacks specialized ICU training, rendering them unable to provide the necessary care. This situation increases the risk of ICU re-admission, mortality, and the development of PICS. ICU transition refers to the process of transferring from the ICU to the general ward, beginning with the ICU doctor's decision and ending when the patient's condition stabilizes in the general ward [50]. ICU liaison nurses (ICULN) lead the care of ICU transition, with the collaborative involvement of other medical workers [105]. A subsequent proposal by scholars in Argentina identified advanced clinical practice, education, collaboration, and research as the main nursing components of ICU transition [106]. A systematic evaluation by Niven and other researchers found that implementing the ICUTCM minimized ICU turnaround time and reduced the likelihood of PICS and ICU re-entry events [107].

6.3. Interventions after ICU

6.3.1. PICS clinic: PICS clinic is a specialized outpatient clinic dedicated to the follow-up and professional support of ICU survivors and patients with PICS [108]. Led by doctors or nurses and involving multidisciplinary teams, the clinic's primary focus is on screening and alleviating the physical, mental, and other symptoms experienced by PICS patients [109]. In addition, it provides continuity of care, ensuring prompt condition assessment and intervention, and reducing the likelihood of hospital or ICU readmission. Successful

implementation of PICS clinics, aimed at mitigating post-ICU problems, has been observed in several foreign nations [108,110,111]. Nevertheless, several studies indicate that the implementation of PICS clinics may not significantly improve the mental health or health-related quality of life for ICU survivors [112–114]. This discrepancy highlights the existing uncertainty regarding the impact of a PICS clinics on ICU survivors [115].

6.3.2. Peer support: Peer support refers to the process that ICU patients and survivors provide each other with empathy, shared experiences, and stories [116]. As a new strategy to intervene in PICS, it can alleviate anxiety, improve quality of life, and enhance self-efficacy in PICS patients [117,118]. There are currently six models of peer support: community-based peer support model, psychologist-led peer support model, ICU follow-up clinic-based peer support model, web-based peer support model, peer support model based on groups within the ICU, and peer mentor model [119].

6.4. Multidisciplinary management

PICS is a condition that includes various clinical symptoms and requires a comprehensive approach to management. This involves addressing physical function, psychology, cognition, and nutrition, among other aspects. To effectively manage PICS, it is recommended to implement an individualized multidisciplinary approach involving specialists, nurses, pharmacists, physiotherapists, psychologists/psychiatrists, occupational therapists, and social workers. This approach should be maintained throughout the entire process of caring for ICU survivors, including in the community and home care settings. By providing comprehensive and individualized treatment, follow-up, and intervention, the multidisciplinary management and treatment can help meet the needs of ICU survivors and their families and support their recovery. Recent studies have also provided evidence for the benefits of multidisciplinary management and treatment in achieving this goal [120–122].

7. Artificial intelligence

As the long-term prognosis of ICU survivors become increasingly concerning, clinical assessment and intervention in PICS have been progressively improved. However, the absence of uniform standards remains a challenge. The complexity of assessment content, the plethora of available assessment tools, and the subjective nature of the assessment process contribute to the challenge of accurately diagnosing PICS and assessing its severity [123]. Additionally, the time-consuming and repetitive nature of assessments can diminish the compliance of healthcare professionals and patients alike. Efficiently managing ICU survivors throughout their journey from ICU admission to post-discharge necessitates substantial financial investment, patient compliance, and effective multidisciplinary management, etc. So, some factors such as inappropriate timing of rehabilitation, inadequate coordination of services, and incomplete treatment can undermine the effectiveness of interventions, ultimately impacting the rehabilitation process by decreasing compliance from both healthcare providers and patients [124].

Recent advances in artificial intelligence have opened new pathways for addressing the challenges associated with the treatment and rehabilitation of PICS. Studies have demonstrated that leveraging computer algorithms in conjunction with logistic regression techniques as well as integrating robotics with cognitive assessment scales can effectively identify subtle cognitive deficits and refine the severity of cognitive impairment in ICU survivors [123,125]. Furthermore, computer-based natural language processing tools can effectively collate the medical records of critically ill patients, providing multidisciplinary management teams with detailed and accurate information, thereby enhancing the diagnostic accuracy and quality of care for PICS patients [126]. The ability of artificial intelligence to process complex data and its faster data processing speed not only enhance the quality of transitional care in the ICU but also formulate and adjust rehabilitation plans for ICU survivors promptly, thereby reducing the risk of readmission and speeding up their recovery process [124,127].

8. Conclusions

The development of science and technology, together with the transformation of the biomedical model, has shifted the focus of medical treatment. Rather than solely aiming to reduce morbidity and mortality rates, the emphasis is now on improving the quality of life and long-term prognosis for critically ill patients and their families. The goal is to restore patients and their families to their pre-disease state as much as possible. Consequently, PICS has become an important area of concern in terms of public health. However, the diagnosis and treatment criteria for PICS still remain unclear. To address this problem, clinicians and researchers should actively explore the clinical manifestations, pathophysiology, and risk factors of PICS, drawing upon existing academic achievements both domestically and internationally. This exploration will enable the formulation of intervention strategies for PICS prevention, as well as diagnostic and therapeutic criteria. Ultimately, these efforts will lead to a reduced occurrence of PICS and improved prognosis for patients.

Ethics

Not applicable.

Data availability statement

The authors declare that no data associated with our study has been deposited into a publicly available repository since no data was

used for the research described in the article.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Xiaofang He: Writing – review & editing, Writing – original draft, Conceptualization. **Yuwei Song:** Writing – review & editing, Conceptualization. **Yuchun Cao:** Writing – review & editing, Conceptualization. **Liying Miao:** Writing – review & editing, Conceptualization. **Bin Zhu:** Writing – review & editing, Conceptualization.

Declaration of competing 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.

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