

Impact of malnutrition on the outcome of critically-ill children: A comprehensive narrative review

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ABSTRACT

Malnutrition presents a universal challenge, affecting millions of children and resulting in severe health consequences. Notably, its consequences within the pediatric population, especially those that necessitate admission to the pediatric intensive care unit (PICU), are of concern. This narrative review discusses the nutritional status, particularly malnutrition, and factors associated that impact the outcome during the PICU stay. Furthermore, the interpretation of clinical conditions and physiological aspects and the understanding of potential interventions together help to analyze the outcome associated with malnutrition. By studying these aspects, this review proposes to contribute a proper understanding of how malnutrition closely influences outcomes in the condition of children admitted to PICUs.

Key words: Children, Malnutrition, Outcome, Pediatric intensive care unit

Malnutrition presents a universal challenge, affecting millions of children and resulting in severe health consequences. Notably, its consequences within the pediatric population are of concern [1]. Children admitted to the pediatric intensive care unit (PICU) are mostly critically ill, and being in such conditions, malnutrition makes their condition more challenging [2,3]. Malnutrition is a condition when there is an imbalance between nutrition intake and the body's nutritional requirements. This condition can get unidentified due to the focus on the medical conditions that are of primary concern. Implications of malnutrition are not just limited to the nutritional deficit but to several other factors, like delay in wound healing, compromised pulmonary function, and a weak immune response.

The mortality rate among such patients is much higher than normally nourished patients. Furthermore, they are exposed to a higher risk of disease-associated complications. Longer stays in the PICU, longer hospital stays, longer mechanical ventilation (MV), and higher chances of acquired infections are some complications that are associated with malnutrition patients [4]. This narrative review discusses the nutritional status and factors associated that impact the outcome during the PICU stay. The objective of this review is to investigate a wide range of fields to understand the role of malnutrition using various tools. Furthermore, the interpretation of clinical conditions and physiological aspects


and the understanding of potential interventions together help to analyze the outcome associated with malnutrition.

Anthropometric measurements and malnutrition

Anthropometric measurements such as weight, height, and body mass index are parameters or tools that help to evaluate the status of malnutrition based on the body's condition. These data categorize the nutritional status-based condition of children as underweight, micronutrient deficit, stunted, or wasting [5]. These parameters are used to monitor the condition of the patient under treatment and engage a medical intervention to overcome the debilitating condition. Nutritional imbalances can be managed better if caught at the right time and can be a constructive effort to prevent severe outcomes. Although anthropometric measurements are important, precision in recording them may face challenges under certain situations. Although anthropometric measurements are important, precision in recording them may face challenges under certain situations such as acute illness or physical deformities. In such conditions, inappropriate anthropometric measurement values cannot rightly define the malnutrition [6].

Pediatric risk of mortality (PRISM) score and malnutrition

One of the tools to study mortality among the pediatric population is the PRISM, which is used for critically ill children. It is a scoring system that differentiates between survival and mortality

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outcomes. The scoring system includes variables that are predictive values for mortality [7]. The PRISM score can be used to predict the length of stay (LOS) in the surviving population admitted to PICUs. The PRISM score is just one of the many parameters studied for the assessment of mortality among patients, and it is not the exact evaluating parameter to predict outcomes in a particular nutritional condition of critically ill children. It focuses on relevant physiological values such as weight for age and other such factors that predict outcomes such as LOS and mortality [8]. As a proposed effort, combining nutritional status with the PRISM score can be a more efficient approach to the prediction of outcomes such as mortality.

The severity of malnutrition

The severity of malnutrition is associated with the risk of mortality in critically ill children admitted to the PICU. Malnutrition is identified by weight loss, stunting, and wasting. According to the World Health Organization, wasting is characterized by low weight for height, stunting is characterized by low height to age, and the underweight category is categorized by low weight for age estimation [9]. All these conditions result from insufficient nutrition. Several scoring tools evaluate the severity of malnutrition. These are specially designed systems that are critical for the assessment of nutritional status. Timely detection of these data helps to engage the nutritional intervention that will impact the clinical outcomes in the children admitted to the PICU [10].

Consequences of malnutrition in the PICU

Malnutrition presents several implications for critically ill children from PICUs. Identifying them and addressing them at the right time prevents further deterioration of the condition of patients. Nutritional deliveries in appropriate amounts and right time overcome the severe outcomes of clinical conditions under which a PICU stay is planned.

Duration of PICU stay

Nutritional deficits in PICU-admitted patients play a major role in their recovery. A compromised nutritional status, resulting in malnutrition, further deteriorates the clinical condition and increases the dependency of patients on different life support systems. This eventually leads to a longer stay in the PICU [11]. A weakened immune system due to malnutrition makes the patients more susceptible to various infections. This makes them more vulnerable and increases the need for close and continuous monitoring of health status. Malnutrition if not corrected tends to delay the recovery period that essentially requires PICU care. Various nutritional interventions are required to be planned in the PICU itself. Close monitoring is done in the PICU, not just for the period of recovery but to prevent relapse of nutritional deficits. Thus, comprehending malnutrition is an ideal way to reduce the duration of the PICU stay.

Duration of hospital stay

A period of recovery plan in the PICU does not necessarily lead to discharge from the hospital. The PICU stay is managed to the time all the vitals of the body are under control [12]. For further assurance and a sustained state of health parameters, further stay in the hospital is necessary. Malnutrition patients especially need to be kept under observation until the nutritional deficit is re-instated. With proper nutritional interventions, the condition of malnutrition can be managed and the stay in the hospital can be reduced.

Need and duration of MV

Malnutrition children with critical illness have a compromised pulmonary function as compared to well-nourished children with similar clinical conditions. With a compromised respiratory, muscle ability to wean in ventilation is challenged. By correcting malnutrition by nutritional supplementation, the need for MV can be managed. Not just the need but also the duration of MV is prolonged in malnutrition children due to the debilitated physical condition, especially respiratory function [13]. A life support system like MV is a factor that is monitored and kept under control until the recovery cycle starts. An increased duration of MV further becomes more challenging if other ventilator-associated complications arise [14].

Mortality

PICU-associated mortality is a major concern among critically ill children. The condition of malnutrition further complicates this situation [15]. Undernourished patients encounter several challenges while undergoing treatment for a critical condition. Their body is deficient in energy and nutrition to combat diseases. An additional support system by replenishing the nutrient level is advised. Under the influence of malnutrition, survival rate is further challenged as the patient can easily succumb to physiological threats and life-threatening complications. Recovery from critical clinical conditions is compromised, and susceptibility to other infections is additionally increased.

Acquired infections

Under the influence of life-threatening clinical conditions, the pediatric population is under PICU care. With continuous medical interventions, the body is challenged and immunity is compromised [16,17]. In such a condition, malnutrition acts as an additional threat due to an undernourished body that fails to build up the immune system even with drug-induced immunotherapy. Such a condition is the main cause of exposure to secondary infections acquired from intensive care itself. Susceptibility to opportunistic infections, bloodstream infections, surgical site infections, gastrointestinal infections, urinary tract infections, skin and soft-tissue infections, septicemia, and systemic infections are some of the primary challenges and complications during a PICU

stay. The condition of malnutrition escalated the chances of these complications to a higher level.

Neurocognitive development

Malnutrition, specifically severe malnutrition, presents crucial implications for neurocognitive development in PICU patients. As compared to well-nourished peers, malnutrition patients are linked to challenging academic, cognitive, and behavioral results [17]. The malnutrition-associated conditions during PICU care exist into adolescence and adulthood. The long-term effects of malnutrition are mostly neglected, and compliance to the instructions and post-recovery of critical illnesses is often ignored. This may affect the academic development as well as the quality of life of the patient.

Inflammation and immune function

Malnutrition greatly affects the immune system of the body, especially under the care of the PICU [18]. A malnutrition body easily succumbs to infections, and in such cases, exposure to higher levels of proinflammatory cytokines is registered. Children exposed to high-protein-energy malnutrition express higher values of inflammatory mediators. Both innate and adaptive immunity are challenged in a condition of malnutrition. The specific factors associated with immunity are compromised, making the immune response a bigger challenge. To maintain a viable immune system, nutritional supplements must provide sufficient protein and amino acids. Proteins and amino acids act as vital agents to maintain immune cells. A well-developed immune system acts as a barrier to prevent infections and comply with vaccines [19].

Quality of life post-PICU discharge

The children who experience malnutrition during their stay in the PICU have a challenging consideration regarding the quality-of-life post-PICU discharge. Both physical and psychosocial well-being are compromised. Children with malnutrition present a higher risk of post-discharge complications. Mortality and hospital readmission are significant among these complications. In some studies, 90-day post-discharge mortality was at a higher risk level among malnutrition patients than without malnutrition. This shows that malnutrition is an important predictor of post-discharge quality of life. Apart from this, readmission chances within 30 days are also a significant factor involved. Importantly, it is observed that malnutrition is also responsible for discharge to a care facility after the PICU. Malnutrition affects the quality of life and thus makes it more important to make the right nutritional assessment and effective implementation of nutritional interventions [20].

Economic burden of malnutrition in PICU

The economic burden of malnutrition in PICU is a major concern. The impact of its implications affects both the patient

and the health-care system. The duration of PICU stay is comparatively longer in the case of malnourished patients than in non-malnourished patients. The longer the stay, the costlier it is to manage the treatment [21]. This indicates that malnutrition is directly relevant to the duration of hospital stay and to the associated cost of treatment. A condition like this makes it a bigger challenge in underdeveloped countries as compared to developing and developed countries.

Nutritional biomarkers

Nutritional biomarkers such as visceral proteins, serum albumin, and cholesterol are crucial markers to assess the nutritional status of critically ill children [22]. However, they cannot act alone to identify the nutritional condition, and other clinical data is required to be taken along. Anthropometric measurements, clinical histories, and other assessments should be obtained to understand the patient's nutritional level in a better way.

Longitudinal studies and follow-up

The long-term effects of malnutrition can be identified by longitudinal studies and follow-up sessions. These investigations allow for monitoring of the condition of patients and relate it to the role of nutritional interventions. The assessment helps to relate to the condition of children admitted to the PICU who were also malnourished and their status after some time [23]. Studies have shown that there was an impact on their anthropometric measurements as per their age due to their history of PICU admission along with malnutrition. The implications are so profound that a need to deploy the right nutritional intervention with timely assessment if required in such a condition.

Malnutrition not only influences morbidities but also increases the chances of other comorbidities. By directly affecting the immune system of the body, malnutrition presents a threat to the escalation of underlying diseases and the onset of new complications. Nutritional supplements and management can correct a decreased nutrition potential to fight new diseases.

Strategies to address malnutrition in the PICU

Recognizing malnutrition in the PICU is a multifaceted task. It includes assessments of nutritional status not only at the time of admission but also during treatment, well-planned nutritional interventions, and future monitoring of the outcomes (Figure 1).

Early nutritional survey/assessment

Performing an early nutritional assessment is critical. Anthropometric measurements, clinical evaluations, and biochemical assays need to be combined to achieve this. Engaging various standardized nutritional screening methods helps to identify patients at risk [24].

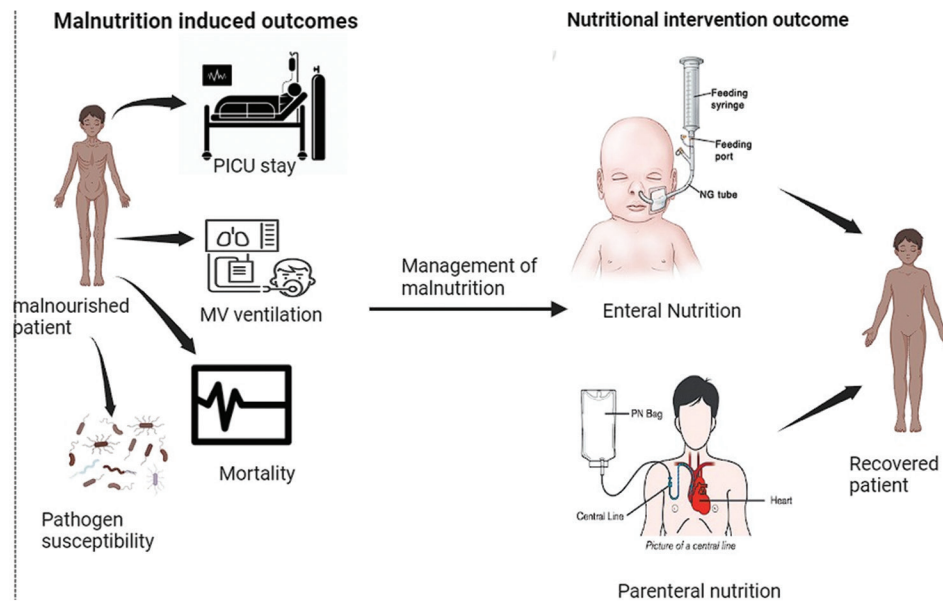


Figure 1: Strategies to address malnutrition in the PICU

Individualized nutritional plans

Based on the specific needs of the patient under treatment, a well-planned nutritional plan can be implemented [25]. Factors such as the severity of malnutrition, underlying conditions, and anthropometric values can be used to plan the customized nutritional plan. These plans include enteral nutrition (EN), parenteral nutrition, micronutrient supplementation, and macronutrient addition.

EN as a priority

Under any possible situation, EN should be preferred as this will activate the mucosal immune system and retain the gut integrity. EN is safe as it does not require an intravenous method, thus preventing the chance of infection [26]. Nutrient absorption through the digestive system is better, and enteral mode ensures this. The enteral mode of nutrition leads to maintenance as well as increased weight, which helps in early recovery. An early application of EN presents positive implications for the outcomes. Proper initiation and adjusting the nutrition regime during EN are positively associated with the patient's recovery.

Close monitoring and adjustment

Timely monitoring of the nutritional status, fluid status, and biochemical values is required. Planning the nutritional delivery according to the patient's need and the demand of the underlying condition should be adjusted and then applied. This will help to reduce complications and standardize nutritional support.

Preventing refeeding syndrome

The condition of electrolyte imbalances and other metabolic discrepancies can be prevented if the approach to attain nutritional level is well calculated. Refeeding syndrome can be prevented by

gradually increasing the nutritional delivery; this becomes a more cautious task in the case of severely malnutrition patients [27]. Close observation of the electrolyte status, particularly phosphorus, during nutritional supplements is advocated.

Post-discharge nutrition support

Monitoring the patient's condition after discharge is crucial to maintain recovery. Strategies need to be planned accordingly to maintain post-discharge nutritional support. Outpatient follow-ups, counseling, and communication with caregivers need to be done. This ensures the sustainability of the procedures and better outcomes of the nutritional intervention.

Training and involving caregivers for planning

Health-care professionals and caregivers are important in planning a nutritional strategy for critically ill children in the PICU [28]. Educating them and training them is crucial to attaining goals of nutritional standards. Updating them and making them aware of the recent advances keep the outcomes of treatments in good ranks. Similarly, parental and caregiver's involvement in the planning of nutritional support is equally important. This enhances compliance with the regime and helps in the recovery of the patient.

Research and quality improvement initiatives

Optimizing the nutritional care protocols with ever-evolving conditions is a need of the time [29]. Continuous research and study in this sector is much appreciated. Research initiatives should be engaged that will elaborate on the assessment of nutritional status, identify the requirements, and present methods of correction [30].

All these strategies together come along to manage the implications of malnutrition in the PICU. It ultimately works

toward the management of critically ill patients and contributes to their well-being.

Ambiguous implications of malnutrition on the outcomes in critically ill children of PICU emphasize the need for monitoring the nutritional status. This narrative review highlights the impact of malnutrition on various aspects, which not just focuses on immediate results but also long-term implications for neurocognitive development, immune function, quality of life post-PICU discharge, and the economic burden on health-care systems.

The severity involved in malnutrition emerges as a determinant of multifaceted outcomes affecting hospital and PICU stays, duration of MV, mortality rates, comorbidities, and susceptibility to acquired infections. Identifying malnutrition as an imposing factor in the PICU environment necessitates the need to deploy adequate nutritional interventions that extend beyond mere caloric supply. Strategies targeting malnutrition must be customized depending on the needs of individual patients. It should be elaborately employed according to the considering the unique needs of each patient and should be integrated into the broader treatment plan.

Moreover, this review emphasizes nutritional interventions and their role in the early and safe recovery of the patient. The right mode of nutrition and applying it at the right time of treatment is the key to the success of the nutritional mode. The malnutrition of the patient relates to several factors that indirectly affect the general condition of the pediatric population under care. The close regulation of immune function with malnutrition defines the upcoming complications that may arise and affect the outcome of the patient. With the latest advancements in the field of healthcare as technological advancements continue to reshape healthcare, the use of innovative tools and effective biomarkers becomes a potential breakthrough to achieve the goal of better nutritional assessment and customizing nutritional interventions.

Ethical consideration involved in the decision-making of nutritional plans is a crucial aspect, especially in cases where the prognosis is poor. It necessitates the aim to choose and apply the intervention that aligns best with compliance with patients' care and benefits. While this narrative review presents an elaborate overview, it also emphasizes the gaps in research and the need to engage longitudinal studies to understand and manage the long-term effects of malnutrition in critically ill children in the PICU.

Future research should be initiated to identify the role of nutritional status in the well-being of the pediatric population under care in the PICU. The role of nutritional biomarkers, the economic aspect of the nutritional study, and innovative nutritional intervention programs, along with the benefits of incorporating advanced technology with management programs is expected.

CONCLUSION

Addressing the implications of malnutrition in the PICU demands an overall approach that identifies both current and long-term results. Technological advancements navigate ethical

considerations and foster ongoing research collaborations. In the process, health-care professionals can align and adjust the nutritional care of critically ill children and improve their outcomes, quality of life, and long-term well-being post-PICU discharge.

REFERENCES

1. Albadi MS, Bookari K. Is undernutrition associated with deterioration of outcomes in the pediatric intensive care unit (PICU): Systematic and meta-analysis review. *Front Pediatr* 2022;10:769401.
2. Kratochvíl M, Klučka J, Klabusayová E, Musilová T, Vafek V, Skříšová T, *et al.* Nutrition in pediatric intensive care: A narrative review. *Children (Basel)* 2022;9:1031.
3. Tekla SG, Kebede RA, Sherman C. The prevalence of malnutrition during admission to the pediatric intensive care unit, a retrospective cross-sectional study at Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia. *Pan Afr Med J* 2022;41:77.
4. Bagri NK, Jose B, Shah SK, Bhutia TD, Kabra SK, Lodha R. Impact of malnutrition on the outcome of critically ill children. *Indian J Pediatr* 2015;82:601-5.
5. Duggan MB. Anthropometry as a tool for measuring malnutrition: Impact of the new WHO growth standards and reference. *Ann Trop Paediatr* 2010;30:1-17.
6. Dawed A, Mekonnen TC, Genetu M, Tadesse SE, Dewau R, Mucche A, *et al.* Comparing the validity of anthropometric measurements in identifying malnutrition status of older age people in Borena district, North Central Ethiopia: A cross-sectional study. *BMC Geriatr* 2022;22:776.
7. Pollack MM, Holubkov R, Funai T, Dean JM, Berger JT, Wessel DL, *et al.* The pediatric risk of mortality score: Update 2015. *Pediatr Crit Care Med* 2016;17:2-9.
8. Bellad R, Rao S, Patil VD, Mahantshetti NS. Outcome of intensive care unit patients using pediatric risk of mortality (PRISM) score. *Indian Pediatr* 2009;46:1091-2.
9. World Health Organization. Guideline: Updates on the Management of Severe Acute Malnutrition in Infants and Children. Geneva: World Health Organization; 2013.
10. Mohialdeen Gubari MI, Hosseinzadeh-Attar MJ, Hosseini M, Mohialdeen FA, Othman H, Hama-Ghareeb KA, *et al.* Nutritional status in intensive care unit: A meta-analysis and systematic review. *Galen Med J* 2020;9:e1678.
11. Sundar VV, Sehu Allavudin SF, Easaw ME. Factors influencing adequate protein and energy delivery among critically ill children with heart disease in pediatric intensive care unit. *Clin Nutr ESPEN* 2021;43:353-9.
12. Wang X, Naito Y, Nakatani H, Ida M, Kawaguchi M. Prevalence of undernutrition in surgical patients and the effect on length of hospital stay. *J Anesth* 2022;36:89-95.
13. Carvalhal FB, Ferreira Peres WA, Fontes Lima GC, Barcellos LH, Do Carmo CN, De Carvalho Padilha P. Impact of energy deficit during hospitalization and biomarkers at admission on clinical outcomes in critically ill children: A longitudinal study. *Clin Nutr ESPEN* 2019;32:70-5.
14. Sood S, Ganatra HA, Perez Marques F, Langner TR. Complications during mechanical ventilation-a pediatric intensive care perspective. *Front Med (Lausanne)* 2023;10:1016316.
15. Amirjani S, Ahmadzadeh N, Behzad A, Dadashi-Noshahr Y, Vahdat Shariatpanahi Z. Undernutrition and 60-day mortality in critically ill children with respiratory failure: A prospective cohort study. *BMC Pediatr* 2023;23:271.
16. Niseteo T, Hojsak I, Kolaček S. Malnourished children acquire nosocomial infections more often and have significantly increased length of hospital stay. *Clin Nutr* 2020;39:1560-3.
17. Verlinden I, Güiza F, Dulfer K, Van Cleemput H, Wouters PJ, Guerra GG, *et al.* Physical, emotional/behavioral, and neurocognitive developmental outcomes from 2 to 4 years after PICU admission: A secondary analysis of the early versus late parenteral nutrition randomized controlled trial cohort. *Pediatr Crit Care Med* 2022;23:580-92.
18. Morales F, Montserrat-de la Paz S, Leon MJ, Rivero-Pino F. Effects of malnutrition on the immune system and infection and the role of nutritional strategies regarding improvements in children's health status: A literature

- review. *Nutrients* 2023;16:1.
19. Briassoulis G. Nutrition monitoring in the PICU. *Pediatr Crit Care Med* 2014;28:579-601.
 20. Woodruff AG, Choong K. Long-term outcomes and the post-intensive care syndrome in critically ill children: A North American perspective. *Children (Basel)* 2021;8:254.
 21. Khlevner J, Naranjo K, Hoyer C, Carullo AS, Kerr KW, Marriage B. Healthcare burden associated with malnutrition diagnoses in hospitalized children with critical illnesses. *Nutrients* 2023;15:3011.
 22. Ong C, Han WM, Wong JJ, Lee JH. Nutrition biomarkers and clinical outcomes in critically ill children: A critical appraisal of the literature. *Clin Nutr* 2014;33:191-7.
 23. Ducharme-Crevier L, La KA, Francois T, Gerardis G, Beauchamp M, Harrington K, *et al.* PICU follow-Up Clinic: Patient and family outcomes 2 months after discharge. *Pediatr Crit Care Med* 2021;22:935-43.
 24. Kerklaan D, Fizez T, Mehta NM, Mesotten D, Van Rosmalen J, Hulst JM, *et al.* Worldwide survey of nutritional practices in PICUs. *Pediatr Crit Care Med* 2016;17:10-8.
 25. Joffe A, Anton N, Lequier L, Vandermeer B, Tjosvold L, Larsen B, *et al.* Nutritional support for critically ill children. *Cochrane Database Syst Rev* 2016;2016:CD005144.
 26. Brown AM, Carpenter D, Keller G, Morgan S, Irving SY. Enteral nutrition in the PICU: Current status and ongoing challenges. *J Pediatr Intensive Care* 2015;4:111-20.
 27. Alsohime F, Assiry G, AlSalman M, Alabdulkareem W, Almuzini H, Alyahya M, *et al.* Barriers to the delivery of enteral nutrition in pediatric intensive care units: A national survey. *Int J Pediatr Adolesc Med* 2021;8:186-90.
 28. Corsello A, Trovato CM, Dipasquale V, Bolasco G, Labriola F, Gottrand F, *et al.* Refeeding syndrome in pediatric age, an unknown disease: A narrative review. *J Pediatr Gastroenterol Nutr* 2023;77:e75-83.
 29. Rungsattatharm L, Kongkiattikul L, Samransamruajkit R, Chomtho S. Achievement of nutritional goals after a pediatric intensive care unit nutrition support guideline implementation. *Clin Nutr ESPEN* 2022;50:277-82.
 30. Valladares AF, Kilgore KM, Partridge J, Sulo S, Kerr KW, McCauley S. How a malnutrition quality improvement initiative furthers malnutrition measurement and care: Results from a hospital learning collaborative. *JPEN J Parenter Enteral Nutr* 2021;45:366-71.

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