Aportación original
Vol. 64
Núm. 2

Clinical features of pediatric patients with prolonged Pediatric Intensive Care Unit stay

Características clínicas de los pacientes pediátricos con estancia prolongada en la Unidad de Terapia Intensiva Pediátrica

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Abstract

Background: Patients with prolonged length of stay (PLOS) in Pediatric Intensive Care Units (PICU) pose clinical and economic challenges. In Mexico, data is limited.
Objectives: To identify the clinical profile and main risk factors of children with prolonged PICU stays.
Materials and methods: A retrospective cohort study of critically ill children was done. PLOS was defined as a stay longer than 14 days. PLOS frequency and patient mortality were described. Clinical profiles of patients with and without PLOS were compared and a logistic regression identified key predictors.
Results: Among patients, 12.2% had PLOS, utilizing 47% of the total bed-days PICU occupancy. Mortality was 8.1% overall and 15.7% among PLOS cases. Children with PLOS significantly differed from those without in terms of illness severity, comorbidities, infections, nutrition strategies, need and duration of organ support, and mortality. Logistic regression identified mechanical ventilation (OR = 2.37) and renal/hepatic replacement therapy (OR = 44.68) as independent predictors of PLOS.
Conclusions: Despite their small proportion, PLOS patients significantly impact PICU resources. Early identification and targeted care strategies are essential to improve outcomes and resource use.

Resumen

Introducción: los pacientes con estancia prolongada (EP) en Unidades de Terapia Intensiva Pediátrica (UTIP) presentan desafíos clínicos y económicos. En México, los datos son limitados.
Objetivo: identificar el perfil clínico y los principales factores de riesgo de niños con EP en UTIP.
Material y métodos: se realizó un estudio de cohorte retrospectiva de niños críticamente enfermos. La estancia prolongada se definió como aquella mayor a 14 días. Se describió la frecuencia de EP y la mortalidad de estos pacientes. Se compararon los perfiles clínicos de pacientes con y sin EP y una regresión logística identificó los predictores claves.
Resultados: entre los pacientes, el 12.2% tenía EP, utilizando el 47% de la ocupación total de días-cama de la UTIP. La mortalidad fue del 8.1% en general y del 15.7% entre los casos con EP. Los niños con estancia prolongada difirieron significativamente del resto en términos de gravedad de la enfermedad, comorbilidades, infecciones, nutrición, necesidad y duración del soporte orgánico, y mortalidad. La regresión logística identificó la ventilación mecánica (OR = 2.37) y la terapia de reemplazo renal/hepática (OR = 44.68) como predictores independientes de EP.
Conclusiones: a pesar de su baja proporción, los pacientes con EP tienen un impacto significativo en los recursos de la UTIP. La identificación temprana y las estrategias de atención dirigidas son esenciales para mejorar los resultados y el uso de recursos.

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Keywords
Intensive Care Units
Hospitalization
Pediatrics

Palabras clave
Unidad de Cuidados Intensivos
Hospitalización
Pediatría

Received: 19/08/2025

Accepted: 26/09/2025

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How to cite this article: Moya-Sánchez C, Ramírez-Flores IZ, Salazar-Rios ME *et al.* Clinical features of pediatric patients with prolonged Pediatric Intensive Care Unit stay. Rev Med Inst Mex Seguro Soc. 2026;64(2):e6814. doi: 10.5281/zenodo.17543877

Introduction

A Pediatric Intensive Care Unit (PICU) provides specialized care to critically ill pediatric patients through life supporting procedures in clinical-surgical settings.[1] Prolonged length of stay (PLOS) in the PICU is a well-established indicator that reflects a subpopulation of patients with greater disease complexity, higher severity of illness, more complications, and increased comorbidity burden. Currently, there is no universally accepted definition of PLOS in PICU,[2] with studies reporting durations between 8 and 30 days, and variability depending on population and criteria.[3,4,5] Three main parameters, or a combination of them,[6] have been used to define PLOS: 1. The 95th percentile of the population's length of stay.[7,8] 2. Three to five times the average stay in the unit.[6,9] 3. The point where the "*tail*" of the length-of-stay distribution begins.[10]

Articles about patients with prolonged PICU stay report a higher prevalence among male patients.[11,12] Over half have comorbidities; notably, oncological comorbidities have been identified as independent predictors of mortality in this group.[13] Previous PICU admissions are also associated with longer stay.[7,14] As for admission sources, 31.3% to 55.4% of patients come from the emergency department[15,6] and 37.3% to 44.2% are post-surgical admissions, of which 92.7% involve cardiac surgery.[16,6] Patients with respiratory illnesses (especially pneumonia),[13,7] cardiovascular disease,[6,7] cerebral palsy and/or global developmental delay,[13,11] or those admitted after cardiopulmonary arrest,[17,6] are more likely to experience PLOS. Finally, complications are more frequent in these patients, with infections being the most common,[4,16] particularly ventilator-associated pneumonia,[16,15] followed by bacteriemia and sepsis.[4,15]

Mortality among children with prolonged PICU stays ranges from 22.9% to 36.8%[11,8] and has been noted to be four to ten times higher than average PICU mortality rates.[6,9] Additionally, a 2.5-fold increase in mortality has been observed after 14 days of hospitalization,[6] with case fatality increasing with each additional day of stay.[14]

Although only a small proportion of the PICU population, between 1.9 and 8%,[9,18] experience PLOS, these patients consume a disproportionate amount of medical devices and supplies,[7,11] accounting for 23 and up to 63%[15,10] of total PICU bed-days which translates into a high consumption of healthcare resources.[16]

In recent years, attempts have been made to understand and reduce PLOS in the PICU, as these cases, though few, not only are associated with more complications, higher mortality,[4,13] impact bed availability[10] and greater resource use,[13] but also represent complex medical, emotional, and financial challenges[19,20] for the children and their families.[21,22] Thus, this study aims to identify PLOS frequency and examine the clinical profile of these patients to aid in early identification and reduce PICU stay.

Materials and methods

A retrospective cohort study (with registration number R: 2023-3603-042) was conducted in 2022 at a tertiary-level PICU in Mexico City. The unit had a total of 15 beds, two designated for transplant patients and two isolation beds for children with highly contagious infectious diseases and averaged approximately 500 admissions annually over the past three years. The study population was critically ill pediatric patients admitted to the PICU, of both sexes, and 1 month to 18 years of age. The unit admitted both medical and post-surgical pediatric patients, including cases of septic shock, severe pneumonia, liver and kidney failure, meningoencephalitis, head trauma, and post-operative care following cardiac, cranial, and transplant surgeries. All PICU admissions during the year were analyzed, regardless of whether they corresponded to the same patient. Patients with incomplete medical records were excluded. The study used convenience sampling without a sample size calculation.

Data from clinical and electronic medical records were captured on descriptive variables including patient demographics (sex, age and nutritional status), clinical characteristics (diagnoses, comorbidities, admission source and reason for PICU admission), severity scores upon PICU admission (PRISM III and SOFA), treatments and interventions (use of mechanical ventilation, vasoactive medications and nutritional support), complications (extubation failure, infections, use of renal or liver replacement therapy, cardiorespiratory arrest), procedures (tracheostomy or gastrostomy), and outcomes (length of PICU stay and mortality). For this study, PLOS in the PICU was defined as a stay of more than 14 days. This cutoff was based on three factors: three times the median (9 days) and the 90th percentile (17 days) of this PICU length of stay, as well as the value most frequently reported in existing literature.

A descriptive analysis was performed. Primary outcomes were PLOS frequency and patient mortality. Secondary outcomes comprised patient diagnosis and comorbidities, complications and resources used. The Kolmogorov-Smirnov test showed that quantitative variables did not follow a normal distribution ($p < 0.001$). Clinical profiles and outcomes were then compared between patients with and without PLOS with nonparametric analysis (Mann-Whitney *U*, Chi square and Fisher's Exact). To identify variables for multivariate analysis, we first evaluated the univariate association between each independent variable and PICU PLOS using

binary logistic regression. Variables with a *p*-value < 0.15 and/or strong clinical plausibility were considered for multivariate analysis. The variables meeting this criterion were: 1. SOFA score upon arrival. 2. Time on mechanical ventilation. 3. Healthcare-associated infection during PICU stay. 4. Time of vasoactive use. 5. Need of gastrostomy and/or tracheostomy, and 6. Use of renal or liver replacement therapy. The set of 6 clinically meaningful variables were included in the final analysis. Backward elimination binomial multiple logistic regression analysis was used to remove the least significant variables and ensure no exclusion of important confounders prematurely.

Results

During the study period, 616 episodes of admission were recorded. After excluding 197 due to incomplete medical records, a total of 419 episodes (378 patients) were included in the study. Table I shows the demographic and clinical characteristics of the studied sample. The median age of patients was 5 years, with a little less than half being female (46.5%) and just over half (53.4%) having an altered nutritional status (40.6% malnutrition, 12.8% overweight/obesity). Most patients (85%) had chronic diseases prior to admission, mainly heart (32.2%) and hemato-oncological diseases (21.0%). Likewise, 36.5% of patients suffered from comorbidity, primarily congenital, endocrine, metabolic and nutritional diseases. Over half of the patients (69.2%) were admitted from the operating room, the most common reasons were post-cardiovascular surgery (28.4%), other postoperative care (20%), and post-neurosurgical procedures (19.6%).

Primary outcomes (PLOS and mortality)

In this study, the median length of stay in the PICU was 3 days, ranging from 1 to 56 days. The 419 episodes included in the analysis accounted for a total of 2,656 PICU bed-days. Among them, 51 patients (12.2%) experienced PLOS, collectively utilizing 1,243 bed-days, which represented 47% of the total PICU occupancy during the study period. As shown in table II, upon admission, patients with PLOS had a median Sequential Organ Failure Assessment (SOFA) score of 8, and a median Pediatric Risk of Mortality III (PRISM III) score of 11. Cardiopulmonary arrests occurred in 29.4% (*n* = 15) of patients with PLOS. The overall mortality rate for the studied population was 8.1 deaths per 100 people (*n* = 34) while the mortality rate within the PLOS subgroup was 15.7 deaths per 100 people (*n* = 8) during the study year.

Table I Demographic and clinical characteristics of the sample studied (*n* = 419)

Male, *n* (%)	224 (53.5)
Age (years), median (IQR)	5 (1.3-11.9)
Nutritional status, *n* (%)	
Malnutrition	170 (40.6)
Normal	195 (46.5)
Overweight/obesity	54 (12.8)
SOFA upon admission, median (IQR)	6 (4-8)
Days of stay in the PICU, median (IQR)	3 (2-6)
Mortality, *n* (%)	34 (8.1)

PICU: Pediatric intensive care unit; IQR: Interquartile Range; SOFA: Sequential Organ Failure Assessment

Secondary outcomes

In the studied cohort, patients with prolonged PICU stays exhibited a similar age distribution to the overall population. A slight female predominance was observed, accounting for 52.9% of the group. One-third of the patients had a diagnosis of congenital or acquired heart disease, while 23.5% had a hemato-oncological condition. Comorbidities were present in 52.9% of patients with PLOS.

Regarding admission sources, 45.1% of patients were admitted postoperatively, of whom 17.6% had undergone cardiovascular surgery, and an additional 37.3% were transferred from general pediatric wards. As seen in table II, healthcare-associated infections were identified in 90.2% of PLOS patients.

In terms of resource utilization among patients with PLOS, all required mechanical ventilation and most (82.4%) needed vasoactive support. Renal or hepatic replacement therapies were necessary in 17.6% of cases. Nutritional support via nasogastric or transpyloric tube was used in 90.2% of patients, and 41.2% required total parenteral nutrition during their stay. Finally, 66.7% of patients underwent either gastrostomy or tracheostomy procedures.

Univariate analysis comparison between patients with and without PLOS

Table II presents six of the 19 clinical and demographic factors compared to evaluate their association with the occurrence of PLOS in the PICU. Notably, no significant differences were observed between patients with PLOS and those without regarding age (p = 0.41), sex (p = 0.32), or nutritional status (p = 0.28). Patients with PLOS were more frequently diagnosed with cardiac disease (33.3%), hematological/oncological disease (23.5%), or were previously healthy (17.6%). A pronounced disparity was observed regarding specific comorbidities, with more than half of the

Table II Clinical profiles in children with vs. without PLOS (*n* = 419)

	PLOS (*n* = 51)	Without PLOS (*n* = 368)	*p*-value
	n (%)	*n* (%)	
HAI	46 (90.2)	106 (28.8)	0.00§
Mechanical ventilation	51 (100)	284 (77.2)	0.00^
Vasoactive support	42 (82.4)	191 (51.9)	0.00§
Mortality	8 (15.7)	26 (7.1)	0.03§
	Median (IQR)	Median (IQR)	
SOFA	8 (6-10)	6 (4-8)	0.00*
PRISM III	11 (8.8-15)	8 (5-12)	0.04*

*Mann-Whitney *U*
§Chi square
^Fisher's Exact
PLOS: Prolonged length of stay; IQR: Interquartile Range; HAI: Healthcare associated infection; SOFA: Sequential Organ Failure Assessment; PRISM III: Pediatric Risk of Mortality III

patients with prolonged stays (52.9%) having one or more comorbidities ($p < 0.001$). The most prevalent comorbidities were central nervous system disorders (13.7%) and congenital conditions (11.8%), with statistically significant differences compared to patients without PLOS ($p = 0.01$).

Furthermore, most patients with PLOS were admitted either from the operating room (45.1%) or from hospitalization wards (37.3%). The most frequent reasons for admission in this group were cardiovascular conditions (29.4%) and post-cardiovascular surgery (17.6%). Although patients without PLOS were also predominantly admitted from the operating room, a statistically significant difference in these admission characteristics was observed between the two groups ($p < 0.001$).

Regarding patient evolution within the PICU, several notable trends were identified. All patients with PLOS required mechanical ventilation, with a significantly greater number of ventilation days (median of 18 days vs. 1 day). Additionally, the PLOS group experienced a higher incidence of extubation failure (80.4% vs. 7.1%) and a greater percentage of patients required respiratory support at the time of discharge from the PICU (60.8% vs. 5.2%), all of which were statistically significant ($p < 0.001$, all). Additionally, a significantly higher proportion of patients with PLOS required vasoactive support (82.4% vs. 51.9%; $p < 0.001$), and they received such support for a longer duration (median of 6 days vs. 0 days). Healthcare-associated infections were also more prevalent in the PLOS group (90.2% vs. 28.8%), with bloodstream infections (35.3%) and healthcare-associated pneumonia (23.5%) being the most common types, both showing statistically significant differences between the groups ($p < 0.001$).

Invasive procedures were also more frequently required in the PLOS group, including renal or liver replacement therapy (17.6% vs. 2.7%), gastrostomy and tracheostomy (66.7% vs. 3.3%), Levin tube or transpyloric feeding (90.2% vs. 21.5%), and parenteral nutrition (41.2% vs. 7.9%). All differences were statistically significant ($p < 0.001$).

Finally, patients with prolonged PICU stay demonstrated higher scores on the SOFA (median of 8 vs. 6; $p < 0.001$) and PRISM III scores (median of 11 vs. 8; $p = 0.04$) upon admission. This translated to a higher incidence of cardiorespiratory arrest (29.4% vs. 7.3%; $p < 0.001$) and more than double the mortality rate (15.7% vs. 7.1%; $p = 0.03$) among patients with prolonged length of stay. All variables presented statistically significant differences between the groups.

Backwards binomial multiple logistic regression model

A backward stepwise multivariate binomial logistic regression was conducted to identify independent predictors of PLOS in the PICU. The final model demonstrated excellent overall fit, statistical significance (Omnibus $\chi^2(2) = 272.91$, $p < 0.001$) and strong explanatory power (Nagelkerke $R^2 = 0.915$). Calibration was good (Hosmer–Lemeshow $p = 0.963$), and no evidence of multicollinearity was detected (Variance Inflation Factor range: 1.05–4.3). The final model was validated using a 70/30 train-test split. In the training set ($n = 293$), the model yielded an AUC of 0.997, while the test set ($n = 126$) showed perfect discrimination with an AUC of 1.000. Among the test cases, 18 patients experienced prolonged LOS. These results suggest the model has strong internal validity, robust predictive performance, and generalizes well to unseen data. Post-hoc power analysis showed the study had moderate power (≈ 72%) to detect OR ≈ 2.0, and excellent power (> 90%) to detect large effects (OR ≥ 2.5).

As shown in table III, the analysis was performed in five steps, resulting in a final model that retained two statistically significant predictors: time on mechanical ventilation ($p < 0.001$; OR = 2.37; 95% C.I. of 1.65-3.4) and use of renal or liver replacement therapy ($p = 0.02$; OR = 44.68; 95% C.I. of 2.37-839.27), which were associated with prolonged PICU stay and remained consistent across all steps of the model.

Discussion

PLOS in PICU poses a substantial challenge for both patients and healthcare providers, as this patient subgroup often requires highly specialized, multidisciplinary care and consumes a disproportionate share of resources. This highlights the critical need to identify and address the factors contributing to PLOS.

To date, the literature reports considerable variability in the prevalence of PLOS in PICU, with estimates ranging from 1.9% to 8%.[9,23] In our cohort, the prevalence of PLOS was notably higher at 12.2%. While variability is expected due to factors such as primary diagnoses, and institutional practices, the observed discrepancy may also reflect the patient population served by a tertiary referral center, which often manages a higher proportion of complex, treatment-refractory, and critically ill cases that inherently require longer hospitalization, thereby inflating the average length of stay. Moreover, differences in PLOS thresholds across studies could explain variations in the reported prevalence.

Consistent with findings in other studies, this subset of patients utilized a disproportionate share of medical devices and supplies. During the study period, they accounted for nearly half of the total PICU occupancy, paralleling results from previous research.[16,10] This substantial usage of PICU bed-days underscores the significant strain on healthcare resources associated with prolonged stays.

In our study, patients with PLOS demonstrated significantly higher SOFA and PRISM III scores at admission compared to those without PLOS, indicating greater severity of organ dysfunction. This was further supported by the higher frequency of critical complications such as cardiorespiratory arrest and the need for renal or hepatic replacement therapy in the PLOS group. In alignment with previous literature,[4,16] our findings revealed that patients with PLOS had 1.9 times higher mortality rate compared to average PICU mortality rates. Although other authors report much higher mortality rates in this population[9,11] this discrepancy can be due to advancements in critical care practices and the availability of multidisciplinary care teams that are characteristic of the hospital where the study was conducted, as well as other institutional differences.

Comparison of our findings with previous studies reveals both similarities and notable differences. Although previous studies have indicated a relationship between younger patients and PLOS;[17,8] within this study, age was not statistically significant to PLOS. This may be due to severity of illness being more evenly distributed across children making age a weak independent factor. Likewise, sex did not prove to be statistically significant within this population as described by other authors;[8,14] this may be due in part to the small differences in proportions between sexes.

Children with comorbidities were statistically more likely to experience PLOS, with congenital conditions being the most frequent comorbidity reported; although the proportions were not as high as those published in other studies.[9,16] Notably, oncological conditions did not emerge as a leading comorbidity in this study as they were classified as the primary diagnosis rather than a secondary condition According to the analysis within, complications are statistically more frequent in these patients, with healthcare associated infections being the most common. Ventilator-associated pneumonia has been reported as the most common infection in some studies,[15,16] but bloodstream infections predominated in ours and others.[24]

A detailed analysis of patients with prolonged stays revealed that a little less than half were postoperative cases, with cardiovascular surgeries representing the most common type of operative admission. This pattern aligns with findings in the existing literature.[6,16] The predominance of postoperative cardiac patients among PLOS cases highlights their substantial contribution to intensive care resource use and emphasizes the need for targeted improvements

Table III Backward elimination logistic regression predicting PLOS in PICU ($n = 419$)

Variable	b	SE	OR (95%CI)	*p*-value
Time on Mechanical Ventilation	0.87	0.19	2.37 (1.65 - 3.40)	< 0.001
Renal/Liver Replacement Therapy	3.80	1.50	44.68 (2.37 - 839.27)	0.02
Constant (intercept)	-10.23	2.20	-	-

Omnibus $\chi^2(2) = 272.91$, $p < 0.001$; Nagelkerke $R^2 = 0.915$; Hosmer-Lemeshow $p = 0.963$; AUC = 0.997 (train), 1.000 (test)
PLOS: Prolonged length of stay; PICU: Pediatric intensive care unit; b: Regression coefficient; SE: Standard error; OR: Odds Ratio; CI: Confidence interval

in perioperative management. Potential areas for intervention include robust preoperative risk stratification, enhanced recovery protocols, and optimization of postoperative care. On the other hand, in our study hospital wards represented the second most common source of admission, in contrast to existing literature, where the emergency department was the second most frequent admission source.[15,6] This deviation may reflect instances of delayed recognition of deterioration in hospitalized patients and highlights the need for enhanced early warning systems and escalation protocols in hospital wards to facilitate timely PICU admissions.

Our findings corroborated that patients with PLOS experienced a higher need for mechanical ventilation and vasoactive support, and greater use of medical devices (gastrostomy tubes, tracheostomy tubes and specialized nutrition), results that reached statistical significance. These findings are consistent with previous studies that have indicated these needs as determining factors in the length of hospitalization.[11,25]

Specifically, our results show that duration of mechanical ventilation is a strong, independent risk factor consistent with benchmarking models in PICU.[26] After adjusting for other variables, each additional day a patient requires mechanical ventilation is associated with an increase of 0.87 in the log odds of prolonged stay (SE = 0.19, $p < 0.001$), corresponding to more than a twofold increase in odds (OR = 2.37, 95%CI: 1.65-3.40). These findings align with previous research, which has identified mechanical ventilation as a key determinant of prolonged ICU stays.[15,16,25]

The inclusion of renal or hepatic replacement therapy in our model proved to be a powerful predictor of prolonged PICU stays. Its use was associated with a 3.80 increase in the log odds of prolonged stay (SE = 1.50, $p = 0.02$), reflecting a markedly elevated risk (OR = 44.68, 95%CI: 2.37-839.27). This is of importance given that previous studies analyze respiratory or cardiovascular dysfunction and do not independently assess other organ failures during PICU stay. This association is likely driven by the severity of underlying diseases in patients, often indicating multi-organ dysfunction and critical illness. Although the odd ratio and confidence interval reflect statistical uncertainty from low therapy prevalence in our sample, the consistent statistical significance and direction of the association suggest a clinically meaningful relationship that warrants attention.

When renal or hepatic replacement therapy, a more direct predictor of PLOS, was included in the model, it may have absorbed much of the predictive power attributed to SOFA in previous models without this intervention. However, it is important to note that SOFA score can still contribute to early risk stratification, as it reflects organ dysfunction at the time of admission and provides a broader measure of illness severity. These findings are consistent with prior studies which show that higher scores on tools assessing patient organ dysfunction significantly extend ICU length of stay.[7,13] As such, it should still be considered when identifying high-risk patients early in their ICU stay.

Our study has several limitations, including a small sample size and its retrospective design, which led to the exclusion of patients with incomplete records. Furthermore, not accounting for within-patient correlation may have slightly underestimated standard errors, as some patients had multiple PICU admissions. However, re-admissions accounted for only 9.7% of episodes and 4 cases of PLOS, suggesting minimal impact on model estimates. Since the primary focus was on episode-level predictors of prolonged stay, each admission was treated as an independent event. While this study identifies key predictors of prolonged PICU stay, further research is needed to validate these findings.[27,28] Prospective studies could also better assess the impact of specific interventions. Despite these limitations, our findings provide valuable insights that are consistent with recent mortality patterns in PICU,[29] and shed light on strong independent factors associated with PLOS. Additionally, this hospital is a referral unit that offers tertiary medical care to the population of the center and south of the country, including transplant services, infectious diseases, as well as medical and surgical conditions, enabling us to generalize our findings to the broader Mexican population. These insights could aid policy development of critical patients to enhance the quality of care provided to patients.

Conclusions

Identifying predictors of prolonged hospital stays is essential for enabling preventive strategies in pediatric intensive care. In this study, 12.2% of patients experienced prolonged stays, slightly higher than previously reported in the literature. Although this proportion is relatively low, they accounted for nearly half (47%) of total bed-days. This subpopulation also had 1.9 times higher mortality compared to those without extended stays, with a statistically significant difference. Notably, increased duration of mechanical ventilation emerged as a strong, independent risk factor: for each additional day on ventilation, the odds of prolonged stay increased by 2.37 times. The use of renal or hepatic replacement therapies also contributed significantly to extended stays. Given these findings, intensivists should prioritize standardized weaning protocols, proactive respiratory care, optimization of renal and hepatic function and multidisciplinary care to better address the complex needs of critically ill children.

Conflict of interest disclosure: The authors have completed and sent the Spanish-translated form of the Declaration for Potential Conflicts of Interest of the International Committee of Medical Journal Editors, and no conflicts of interest were reported related to this article.

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