Clinical Severity as a Predictor of Nursing Workload in Pediatric Intensive Care Units: A Cross-Sectional Study

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Background: *Increased nursing workload (NW) is associated with increased incidence of adverse events. In adult ICUs, one of the factors that increase NW is the severity of illness; however, this has not been adequately investigated in pediatric intensive care unit (PICU).* ***Aim:*** *To explore potential association between clinical severity of critically ill children and NW in PICU.* ***Methods:*** *A descriptive, correlational, cross-sectional study design was employed. Data were collected from three PICUs of Athens, Greece, during November 2015 to March 2016, using a sample of 58 pediatric patients. The Pediatric- Nursing Activities Score (P-NAS) and the Therapeutic Intervention Scoring System 28 (TISS-28) were used to measure NW and the Pediatric Logistic Organ Dysfunction (PELOD) to assess clinical severity. Demographic and clinical variables of the children were also investigated. Multiple linear regressions were used to identify NW predictive factors, at 5% significance level.* ***Results:*** *Participants' median age (interquartile range [IQR]) was 38.5 (7.0–127.0) months and 50% of them were male. PELOD score was significantly correlated with NW scores on the first day of hospitalization in PICU (P-NAS: $\rho = .319$, $p = .020$, TISS-28: $\rho = .547$, $p < .0001$) and with NW during total PICU stay (TISS-28: $\rho = .483$, $p < .001$). The PELOD ($\beta = .694$, $p = .052$) and the elective surgery ($\beta = -13.12$, $p = .01$) were predictors of the P-NAS on the first day of hospitalization, and the PELOD ($\beta = .563$, $p = .029$) and the emergency surgery ($\beta = 16.09$, $p = .01$) were predictors of the P-NAS during total PICU stay. The PELOD ($\beta = .509$, $p = .001$) was a predictor factor of the TISS-28 score on the first day of PICU hospitalization and the PELOD ($\beta = .371$, $p = .003$) and the age ($\beta = .036$, $p = .005$) were predictors of the TISS-28 score during total PICU stay.* ***Conclusions:*** *The clinical severity is a predictive factor of NW required in PICUs.*

Keywords: clinical severity; nursing workload; pediatric logistic organ dysfunction, pediatric intensive care unit

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INTRODUCTION

Nursing workload consists of the time spent by nursing staff to perform the activities for which they are responsible, whether their actions are directly or indirectly related to patients' care. These activities can change according to patient's dependency degree, complexity of the disease, characteristics of the institution, work processes, physical layout, and nature of the professional team (Altafin et al., 2014).

Pediatric intensive care units (PICUs) are specialized hospital departments, which provide care to infants, children, and adolescents who are suffering from life-threatening illnesses or injuries (Wheeler, Wong, & Shanley, 2014). PICUs patients may require different levels of care, because they present a variety of pathological features and clinical severity (Carmona-Monge et al., 2013). The PICUs are departments with an increased nursing workload and they require commitment, attention, and specific competencies from healthcare professionals (Campagner, Garcia, & Piva, 2014).

There is a variety of nursing workload tools which determine the actual care needs of intensive care unit (ICU) patients and the appropriate nurse/patient ratio (Vincent and Moreno, 2010). Two of these tools are the Therapeutic Intervention Scoring System 28 (TISS-28) (Miranda, de Rijk, & Schaufeli, 1996) and the Nursing Activities Score (NAS) (Miranda et al., 2003). The importance of measuring nursing workload in the ICU has been supported by published data showing the relationship between nursing workload and patients' safety. Increased nursing workload is associated with increased incidence of adverse events, such as prolonged length of stay (LOS), infections, medication administration errors, falls, and deaths (Carlesi, Padilha, Toffoletto, Henriquez-Roldán, & Juan, 2017; Giakoumidakis et al., 2011). So, it is vital to elucidate and identify the factors that influence nursing workload of pediatric patients in PICUs. In critically ill adults, one of the factors that increase nursing workload is the severity of illness. Significant correlations between nursing workload and clinical severity tools, such as the Acute Physiology and Chronic Health Evaluation (APACHE) II (Kiekkas et al., 2007; Nogueira, Santos, Mataloun, & Moock, 2007) and the Sequential Organ Failure Assessment (SOFA) (Altafin et al., 2014; Dede et al., 2018) have been reported in adult ICUs. However, the relationship between clinical severity of children and nursing workload has not been adequately investigated in PICU.

AIM

We aimed to explore the correlation between the clinical severity of critically ill children and nursing workload in PICUs.

METHOD

Design

We performed a descriptive, correlational, cross-sectional study.

Sample and Setting

The study was carried out in three PICUs in three public children hospitals located in Athens, Greece. The sampling of ICUs was convenience sampling. However, in Greece, there are only 6 PICUs with 45 beds in total. The three PICUs of our study represent approximately 53% of total PICUs beds in Greece, and they admit children from all over the country. The sample consisted of all hospitalized children in these PICUs during the study period, provided that they fulfilled the following inclusion criteria: (a) age from 29 days to 16 years and (b) with at least 24 hours stay in the PICU. Readmissions were considered as new admissions. Of the 69 patients hospitalized to the PICUs over the study period, 58 children were eligible for participation in the study and were included in the analysis.

Data Collection

Data collection was performed for at least 1 month in each PICU. Overall, the study lasted for 15 weeks, encompassing the period between

November 2015 and March 2016. The nursing workload was measured using the Greek version of Pediatric-Nursing Activities Score (P-NAS) (Miranda et al., 2003; Nieri et al., 2018) and the TISS-28 (Miranda et al., 1996). These scales are two scoring systems, developed to evaluate nursing workload and predict the time of each nursing care (Chang, Yu, & Chao, 2019).

The NAS consists of 23 items, with 5 items being divided into 2–3 subitems. NAS score is expressed as the percentage of time spent by a nurse on care-related tasks per ICU patient per 24 hours. The sum of scores of the 23 items ranges from 0% to 177% (Miranda et al., 2003). P-NAS has been validated in Greek PICUs in a previous study (Nieri et al., 2018). In P-NAS, PICU-specific interventions have been added on existing items. For instance, in item 6 (mobilization and positioning) the item "hug" has been included. Moreover, in item 16 (quantitative urine output measurement) the "weighting of diaper" was added, in item 7 (support and care of relatives and patient) the "training of parents," and in item 16 (hemofiltration techniques, dialysis techniques) the "plasmapheresis" was added (Nieri et al., 2018). The number of items and their scores in P-NAS are the same as NAS.

The TISS-28 is comprised of 28 items, the scores of which are ranged from 1 to 8. Each TISS-28 point corresponds to 10.6 minutes of nursing work in an 8-hour period, which means that the average work delivered by a nurse is equal to 46 TISS-28 points per 8-hour shift (Miranda et al., 1996). TISS-28 is an appropriate tool for assessing nursing workload in adult and pediatric patients (Campagner et al., 2014; Miranda et al., 1996). In the current study, nursing workload was recorded daily, in the morning shift, until discharge of the children from the PICUs, by the same researcher. We calculated the mean workload per patient with the following equation: sum of nursing workload per patient/total observation per patient. For analyses, we calculated the means of the entire sample of patients.

Moreover, the Pediatric Logistic Organ Dysfunction (PELOD) was used to evaluate the children's clinical severity and organ dysfunction (Leteurtre et al., 2003). The PELOD score addresses six organ systems (neurologic, cardiovascular, hepatic, respiratory, hematologic, and renal) and 12 variables. Each variable is assigned points (0, 1, 10, or 20) based on the level of severity. The maximum number of points for an organ is 20, and the maximum PELOD score is 71 (Leteurtre et al., 2003). PELOD was recorded on the first day of the children's hospitalization in PICUs.

Additionally, we used a short form for basic demographic information (age, gender) and clinical data, such as the type of admission (medical, emergency surgery, or elective surgery), the length of PICU stay, and the clinical outcome in the PICU. PICU admissions due to reasons not involving surgery were defined as medical admission. Emergency surgery was defined as surgery that needs to be performed within 24 hours, while elective surgery was every surgery scheduled ≥24 hours prior.

Ethical Issues

The research was carried out in accordance to Helsinki's Declaration (Carlson, Boyd, & Webb, 2004). The protocol was approved by the Ethics Committee of the Department of Nursing, National and Kapodistrian University of Athens (Register Number: 180), and by the Ethics Committees of the three Children Hospitals (Register Numbers: 14448/22-10-2015; 146/13-5-2015; 5415/11-5-2015). Prior to participants' enrollment into the study, informed consent of their legal guardians was acquired. Patients' personal data remained anonymous at all stages of the study. The study was noninvasive and did not involve any risk or harm to the patients.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 24.0. The normality assumption for continuous variables was evaluated by using the normal Q–Q plots, the coefficient of skewness, and normality test

(Kolmogorov–Smirnov, Shapiro–Wilk) (Mishra et al., 2019). The P-NAS and TISS-28 score followed a normal distribution. Categorical data are presented as numbers and percentages; continuous data are expressed as mean (±standard deviations [*SD*s]) or medians (interquartile ranges [IQRs]), as appropriate. Spearman's correlation was used to identify the correlation between nursing workload and PELOD, between nursing workload and age, and between nursing workload and LOS. One-way ANOVA and multiple comparison analysis tests (Fisher's least significant difference test; reported mean difference and 95% confidence interval [CI] of mean difference) were used to identify the difference between the nursing workload and types of admission. T-test (reported mean difference and 95% CI of mean difference) was used to explore the differences of nursing workload scores across outcome. Multiple linear regression models were tested to identify the predictive factors of nursing workload within the first 24 hours and throughout the patient stay in the ICU. The level of statistical significance set at $\alpha = .05$.

RESULTS

Demographic and Clinical Characteristics

During the study period, 58 pediatric patients hospitalized in the PICUs met the inclusion criteria. The median age (IQR) of the sample was 38.5 months (7.0–127.0) and 50% of the participants were male. The largest percentage of patients were admitted to PICU for medical treatment (63.8%). The observed mortality was 3.5%. The median score of PELOD was 2.0 (1.0–11.0). Additional demographic and clinical data of the sample are presented in Table 1.

Nursing Workload

In total, 424 daily measurements were obtained with each nursing workload scale. The mean nursing workload was calculated for all the patients ($n = 58$), however the nursing workload on the first day of PICU admission was recorded only for 53 patients. The mean nursing workload (±*SD*) on the first day of hospitalization in PICU was 73.73 (±19.14) for P-NAS and 24.38 (±7.99) for TISS-28. The mean nursing workload (±*SD*) during total PICU stay was 66.45 (±13.85) for P-NAS and 23.66 (±7.09) for TISS-28 (Table 2).

Associations of Nursing Workload Scores and the PELOD Score

Table 3 shows the correlations between PELOD score and nursing workload scores. The P-NAS score on the first day of hospitalization in PICU and the PELOD were correlated, positively and statistically significantly ($\rho = .319$, $p = .020$), as well as TISS-28 score on the first day of hospitalization and PELOD score ($\rho = .547$, $p < .0001$) and TISS-28 score during PICU stay and PELOD score ($\rho = .483$, $p < .0001$). However, there wasn't any significant correlation between P-NAS score during PICU stay and PELOD score.

Differences of Nursing Workload Scores Across Demographic and Clinical Characteristics

There was a statistically significant difference among different types of admission with regard to the mean P-NAS scores on the first day of hospitalization ($F = 4.089$, $p = .023$). This difference occurred between elective surgery versus medical admission [mean difference (95% CI); -13.84 (-25.12, -2.49); $p = .018$)] and between elective surgery versus emergency surgery admission [-22.03 (-40.79, -3.26); $p = .022$], with the lowest [63.05 (±11.60)] and highest P-NAS [76.86 (±20.04)] scores being observed in children admitted after elective and emergency surgeries, respectively. Additionally, there was a difference of mean P-NAS and TISS-28 scores between the children who died and those who were discharged. Specifically, the children who died P-NAS score had significantly higher mean P-NAS score on the first day of hospitalization [mean difference (95% CI); 27.04 (0.13, 53.95); $p = .049$)] and during PICU stay [mean difference (95% CI); 21.77 (2.54, 40.99); $p = .027$], and higher mean TISS-28 score on the first day of hospitalization [mean difference (95% CI); 13.12 (2.05, 24.19); $p = .021$)] and during PICU stay [mean difference (95% CI); 13.49 (3.74, 23.23); $p = .008$)] compared to those who survived. Moreover, age correlated positively and statistically significantly with the TISS-28 score on the first day of hospitalization

TABLE 1. Clinical and Demographic Characteristics of the Sample

Patients' Characteristics (*N* = 58)	
Gender, *n* (%)	
Male, *n* (%)	29 (50.0%)
Female, *n* (%)	29 (50.0%)
Age, *median (IQR)*, in months	38.5 (7.0–127.0)
Main diagnoses on admission *n* (%)	
Medical	37 (63.8%)
Elective surgery	15 (25.9%)
Emergency surgery	6 (10.3%)
Length of stay, *median (IQR)*, in days	4.50 (2.0–9.25)
Outcome, *n* (%)[a]	
Survived, *n* (%)	55 (96.5%)
Died, *n* (%)	2 (3.5%)
PELOD, *median(IQR)*	2.0 (1.0–11.0)

Note. IQR = interquartile range; PELOD = Pediatric Logistic Organ Dysfunction.
[a]one child had unknown outcome.

TABLE 2. Scores of TISS-28 and P-NAS on the First Day of Hospitalization and During Total PICU Stay

Nursing Workload	Scores		
	Mean (±*SD*)	Median (IQR)	Min - Max
First day of hospitalization			
TISS-28 (*N* = 53)	24.38 (±7.99)	23.00 (17.50–30.50)	11.00–44.00
P-NAS (*N* = 53)	73.73 (±19.14)	72.50 (58.50–87.65)	39.20–112.10
During total PICU stay			
TISS-28 (*N*= 58)	23.66 (±7.09)	22.00 (18.79–27.94)	11.00–40.45
P-NAS (*N*= 58)	66.45 (±13.85)	64.91 (55.39–72.20)	48.03–105.50

Note. PICU = pediatric intensive care unit; P-NAS = Pediatric-Nursing Activities Score; TISS-28 = Therapeutic Intervention Scoring System 28.

(ρ = .380, p = .005), the TISS-28 score (ρ = .382, p = .003) and the P-NAS score during PICU stay (ρ = .312, p = .017). Finally, LOS correlated positively and statistically significantly with the P-NAS score on the first day of hospitalization (ρ = .271, p = .049), the TISS-28 score on the first day of hospitalization (ρ = .526, p < .0001), and the TISS-28 score during PICU stay (ρ = .498, p < .0001). No other statistically significant differences between nursing workload scores and demographic or clinical characteristics were found.

Tables 4–6 show that the PELOD score was a predictive factor of nursing workload. More specifically, PELOD score was a predictive factor for P-NAS score of their total PICU stay (β = .563, p = .029) and a predictive factor of the TISS-28 score on the first day of PICU stay (β = .509, p = .001), as well as of their total PICU stay (β = 0.371, p = .003). As for the type of patients' admission, elective surgery admission (β = −13.12, p = .01) predicted P-NAS scores on the first day of hospitalization, while the emergency surgery admission (β = 16.09, p = .01) was a predictive factor of the P-NAS score during PICU stay. Moreover, age was a predictive factor of TISS-28 score required by patients during their total PICU stay (β = .036, p = .005).

TABLE 3. Spearman's Correlation Between PELOD Score and Nursing Workload Required on the First Day of PICU Hospitalization and During Total PICU Stay

Nursing Workload	PELOD Score
P-NAS on first day of hospitalization	ρ= .319[a], p-value = .020
TISS-28 on first day of hospitalization	ρ = .547[b], p-value < .0001
P-NAS during total PICU stay	ρ = .229, p-value = .099
TISS-28 during total PICU stay	ρ = .483[b], p-value < .0001

Note. PELOD = Pediatric Logistic Organ Dysfunction; PICU = pediatric intensive care unit; P-NAS = Pediatric-Nursing Activities Score; TISS-28 = Therapeutic Intervention Scoring System 28.
[a]Correlation is significant at the 0.05 level (two tailed).
[b]Correlation is significant at the 0.01 level (two tailed).

TABLE 4. Multiple Linear Regression Analysis of the Predictive Factors of the P-NAS Score on the First Day of PICU Hospitalization

Variables	Dependent Variable			
	P-NAS Score on the First Day of Hospitalization			
	β	Standard error (β)	95% CI	p-value
Type of admission (reference category: medical)				
Elective surgery	−13.12	5.430	−24.20 to −2.21	.01[a]
PELOD score	.694	.348	−0.005 to 1.39	.052

Note. CI = confidence interval; PELOD = Pediatric Logistic Organ Dysfunction System; P-NAS = Pediatric-Nursing Activities Score. R^2 = 0.16; ANOVA: F = 5.85, p = .005.
[a]Significant at the 0.05 level.

DISCUSSION

According to our knowledge, this is the first study to report associations among P-NAS, TISS-28, and PELOD scales in a sample of pediatric patients hospitalized in Greek PICUs. In the current study the demand requirements for nursing care within the first 24 hours of PICU admission in the PICU was higher compared to those of subsequent days. This is due to the improvement in most patients' medical condition during the intensive treatment, thus less nursing care was required. Moreover, TISS-28 and P-NAS scores tend to be higher at admission due to the high dedication of the staff, the performance of the admission standard procedures, and the precise and quick interventions and care upon admission, which demand a high workload from the nursing staff. This finding is also supported by other studies (Campagner et al., 2014; Romano, Garcia, Silva, Moura, & Nogueira, 2019). The mean NAS score and the mean TISS-28 score of the first 24 hours in the PICU, as well as during PICU stay, identified by the present study, fall within the range of values reported by other studies, which have been carried out in PICUs (Bruyneel et al., 2019; Campagner et al., 2014; Lucchini et al., 2014) and in adult ICUs (Altafin et al., 2014; Gouzou, Karanikola, Lemonidou, Papathanassoglou, & Giannakopoulou, 2015; Romano et al., 2019).

Another finding of our study is that the P-NAS on the first day of hospitalization differed significantly in relation to the type of admission. The highest scores were observed in children admitted after emergency surgeries. There are only two earlier studies, in adult ICUs, that compared nursing workload according to the type of admission, which reported similar results (Altafin et al., 2014; Romano et al., 2019). More specifically, the study of Romano et al. (2019), that analyzed 211

TABLE 5. Multiple Linear Regression Analysis of the Predictive Factors of the P-NAS Score During PICU Stay

	Dependent Variable			
	P-NAS During Total PICU Stay			
Variables	β	Standard error (β)	95% CI	p-value
Type of admission (reference category: medical)				
Emergency surgery	16.093	6.038	3.97–28.22	.01[a]
PELOD score	.563	.251	0.06–1.07	.029[a]

Note. CI = confidence interval; PELOD = Pediatric Logistic Organ Dysfunction System; PICU = pediatric intensive care unit; P-NAS = Pediatric-Nursing Activities Score. R^2 = 0.17; ANOVA: F =6.288, p = .004.
[a]Significant at $p \leq .05$ level.

TABLE 6. Multiple Linear Regression Analysis of the Predictive Factors of the TISS-28 on the First Day of PICU Hospitalization and During Total PICU Stay

Variables	Dependent Variable							
	TISS-28 on the First Day of Hospitalization				TISS-28 During Total PICU Stay			
	β	Standard error (β)	95% CI	p-value	β	Standard error (β)	95% CI	p-value
Age (months)	.024	.014	−0.004–0.053	.096[b]	.036	.012	0.01–0.06	0.005[a]
PELOD score	.509	.137	0.23–0.79	.001[a]	.371	.118	0.14–0.61	0.003[a]
	R^2 = 0.26; ANOVA: F = 10.01, p < .0001				R^2 = 0.29; ANOVA: F = 11.65, p < .0001			

Note. CI = confidence interval; PELOD = Pediatric Logistic Organ Dysfunction System; PICU = pediatric intensive care unit; TISS-28 = Therapeutic Intervention Scoring System 28.
[a]Significant at $p \leq .01$ level. [b]Significant at $p \leq .10$ level.

patients admitted to the ICU of a hospital in the city of São Paulo, in Brazil, identified a significant association between the nursing workload required for patients on the first ICU day and the type of admission (p = .025). Moreover, another investigation showed that the type of ICU admission was one of the variables associated with the differences in nursing workload (p = .014), and that the highest NAS values were identified for patients admitted after emergency surgery (Altafin et al., 2014).

In the present study, the clinical severity and organ dysfunction, as determined by the PELOD score were correlated, positively and statistically significantly with the nursing workload on the first day of hospitalization, as well as, the nursing workload during the PICU stay. The relationship between PELOD score and the nursing workload in PICU has not been explored until now. In general, the relation between nursing workload and patients' severity has been investigated, mainly, in adult ICUs. One survey conducted in Brazil using one ICU sample of adults investigated the correlation between NAS and the APACHE II by Pearson's coefficient and found a positive correlation (Nogueira et al., 2007). Moreover, other studies also performed in adult ICUs, have found a positive correlation between NAS and the SOFA (Altafin et al., 2014; Dede et al., 2018). Additionally, in another study, in a Greek General ICU, Pearson's correlation coefficient between APACHE III and the nursing workload measured by NAS was statistically significant and equal to .51 (p < .01) (Kiekkas et al., 2007).

Another finding of the current study was that the PELOD was a predictive factor of nursing

workload required, which is reported for the first time in the literature. More specifically, the PELOD score was a predictor factor of the P-NAS during total PICU stay and a predictor factor of the TISS-28 score on the first day of PICU stay and of total PICU stay. Frey, Hossle, Seiler Sigrist, and Cannizzaro (2013) measured the workload of residents in a PICU with the nine equivalents of nursing manpower use score (NEMS) and compared this value with the severity of patients, as was assessed by the Pediatric Index of Mortality (PIM). However, they found that the PIM on admission was not a predictor of nursing workload (Frey et al., 2013). On the contrary, in another study, in an adult ICU, was found that the risk of death, calculated by Simplified Acute Physiology Score (SAPS) 3, was a predictive factor for the NAS on the first day of ICU admission and that the risk of death according to the Logistic Organ Dysfunction Score (LODS) was predictor of workload during ICU admission (Romano et al., 2019).

Moreover, we found that the children who died had significantly higher nursing workload not only on the first day of hospitalization, but during the total PICU stay too. Similar results have been found in other studies (Dede et al., 2018; Lucchini et al., 2014; Romano et al., 2019). For instance, in one investigation the mean NAS for patients who died was 66.22 (±3.06) significantly higher than patients who survived 62.09 (±5.46) (p = .039) (Dede et al., 2018). Thus, critically ill patients who deteriorate to death in the ICU require more nursing workload than those who are less critical and survive their intensive care stay.

Limitations

The present study has some limitations. The study was conducted in only three PICUs, which were located in the city of Athens and not randomly selected. Moreover, the sample size was relatively low. The principal investigator was not accountable for the provided care in the study PICUs since she was not a staff member. In case of incomplete documentation of nursing interventions in patients' health records, the mean workload scores reported in the current study may have been underestimated. Another, limitation is that the staff to patient ratio was not investigated, information that might have been relevant to the parameters investigated in the current study.

Implications and Recommendations for Practice

This study provided evidence on the associations among the clinical severity of critically ill children, type of admission, and the nursing workload required by PICU patients. Nurse administrators should consider the effect of PICU patient severity of illness on nursing workload to define the appropriate nurse to patient ratios in order to ensure the quality and safety of care of critically ill children. The results of our research should be further investigated in another study with a larger sample of pediatric patients. It is also important to elucidate which one of the available pediatric severity scales is the most effective predictor of the nursing workload.

CONCLUSIONS

The type of admission in the PICU and the clinical severity, as was calculated by PELOD score, seem to predict nursing workload on the first day of children's admission in PICU or throughout their PICU stay.

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