Research Article

Develop and Validate Patient Acuity-based Nursing Assignments Model for Critical Care Units

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Abstract

Introduction: This study aims to develop and validate a patient acuity-based nursing assignment model tailored for critical care units. Traditional nurse-to-patient ratio models often fail to address patient complexity, leading to inefficiencies, nurse burnout, and poor patient outcomes. By integrating patient acuity and nurse expertise, the proposed model ensures equitable workload distribution, improves care quality, and enhances staff satisfaction. The study highlights the need for evidence-based, adaptive staffing strategies in intensive care settings.

Methodology: This quantitative study used the Delphi technique to develop and validate a patient acuity-based nursing assignment model for critical care units. Expert opinions from three rounds informed the model. Using Therapeutic Intervention Scoring System 28, checklists, and questionnaires, validated through pilot testing, the model ensures equitable nurse assignments and improved care quality.

Results: The study revealed that most nurses were female with moderate experience and balanced qualifications. Current assignment models were easy but required improvement. Medical intensive care unit and Emergency Medical Surgical Intensive Care Unit had the highest acuity and workload. More nurses led to complications and better outcomes. Expert consensus validated the model, recommending fair nurse distribution per intensive care unit (ICU).

Conclusion: This study developed and validated a patient acuity-based nursing assignment model to address mismatches in traditional ICU staffing. By integrating acuity scores and nurse competencies, the model improved workload balance, care quality, and staff satisfaction. Validation confirmed its reliability and applicability. The study highlights the necessity and feasibility of data-driven, equitable staffing in critical care, offering practical insights for nursing practice, education, administration, and research.

Keywords: Critical care units, develop, patient acuity-based nursing assignment model, teaching hospital, validate

Introduction

To ensure high-quality healthcare, many advocate for policies that mandate specific nurse-to-patient ratios in hospitals. Research shows that adequate staffing improves patient outcomes by reducing readmissions, complications, and mortality rates.[1] Balanced workloads also decrease nurse burnout and turnover, leading to greater job satisfaction. Obtaining resources for quality patient care is a major responsibility of nurse leaders.[2]

Unlike other members of the healthcare team, nurses spend the most time with patients.[3] Therefore, their assignments critically impact patient care and the medical staff's daily workload.[4] Historically, nursing assignments have been based on simple factors like room proximity, mandated ratios, and medical diagnoses, rather than a scientific assessment of a patient's changing needs.[5,6] This uninformed approach can result in unequal and stressful assignments for nurses.[4]

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A more effective strategy is a scientific approach to staffing that considers the dynamic demands of patient care.[5,7] This method allocates nurses based on patient acuity levels and the nurses' own workloads and skills, ensuring a balanced distribution of assignments.[8] This not only benefits patients with more appropriate care but also improves nurse satisfaction and retention.[2,6] Fair and balanced assignments also mitigate issues like patient wait times, overtime, and privacy concerns, which can arise from an inefficient distribution of complex cases.[4]

Executive decisions regarding staffing, training, and assignments are crucial for properly allocating resources, including the number of nurses, their skill mix, education, and experience.[9] By adopting a scientific method for nursing assignments, hospitals can address nurse shortages and turnover more effectively.[6]

A descriptive qualitative study was conducted in Norway to explore managerial experiences with the RAFAELA patient classification system.[10] The study involved 10 informants holding various managerial roles who provided insights based on their use of the system, which included data from 49 patients. Findings indicated that managers found the RAFAELA system valuable as it offered reliable information on nursing activities and patient care needs. Participants viewed the system as an important tool that created a common framework for discussing nursing workload, staffing, and patient allocation. The study recommended continued use of RAFAELA to support informed decision-making and improve communication around nursing resources and care planning.

A study conducted in a private hospital in Turkey to evaluate the validity and reliability of the Turkish version of Perroca's Patient Classification System (PCT) for assessing patient acuity and nursing workload. The study involved 300 hospitalized patients and used two independent raters to score patient care needs using the PCT scale. Findings confirmed that the tool demonstrated acceptable validity and inter-rater reliability, making it a potentially useful instrument for nurse managers to track workloads and assign staff accordingly. The authors recommended broader application of the tool and further comparative research across different hospitals and clinical populations to enhance its generalizability and effectiveness in varied healthcare settings.[11] The aim of the study was to assess the existing nursing assignment pattern in critical care units, evaluate nurses' satisfaction and patient outcomes based on the current assignment model, develop a patient acuity-based nursing assignment model for critical care settings, and validate the developed model for its effectiveness and applicability.

Methodology

This study employed a quantitative-exploratory sequential design. The research approach for this study involved the use of the Delphi method to systematically gather expert consensus and thereby develop and validate a patient acuity-based nursing assignments model specifically designed for critical care units. A total of 25 Delphi experts and 25 staff nurses were purposively selected based on intensive care unit (ICU) qualifications and experience, with inclusion of nurses having at least one month of ICU exposure. The Delphi process was conducted in three rounds involving open-ended questionnaires, expert checklists, and a Likert scale for prioritization. Data were collected using observational checklists, Therapeutic Intervention Scoring System 28 (TISS-28) acuity scoring, satisfaction measures, and structured questionnaires**.** Content validity was established through content validity index (CVI) at item, expert, and scale levels-CVI $\geq$ 0.90, while reliability testing yielded 0.80, and TISS-28 showed 0.76. A pilot study with 10 nurses ensured clarity and feasibility. Ethical clearance was obtained from the committee in MGM Dental College, Kamothe, Navi Mumbai, sent an ethical license under registration IN/CON/154/05/2024 on the 27th of May 2024. All participants expressed written consent and reading the Participant information sheet. Data analysis employed frequency, percentage, Wilcoxon signed-rank test, and Kendall's tau-b correlation**.** The validated model, piloted with 20 nurses, classified care activities, calculated nursing care hour**s**, and demonstrated feasibility, acceptance, and improved workload balance.

Results

The study revealed that most nurses were female (92%), with 36% having 3–4 years of experience and 32% having 5 or more years; qualifications were balanced between BSc(Nursing) (44%) and General Nursing and Midwifery (48%). Nurses perceived the current assignment model positively, with 76% believing it improved outcomes and 88% reporting reduced workload, though only 52% felt able to provide quality care. In critical care units, most nurses had 1–3 years' experience (40.4%), and senior staff were scarce (6.4%). Mortality was highest in the medical intensive care unit (MICU) (40%) and Emergency Medical Surgical Intensive Care Unit (EMSICU) (44.4%), while the coronary care unit (CCU) had no mortality and the best recovery rate (80%).

Figure 1 compares patient and nurse numbers per shift across ICUs (surgical intensive care unit [SICU], MICU, EMSICU, CCU, Cardio Vascular Thoracic Surgery Intensive Care Unit

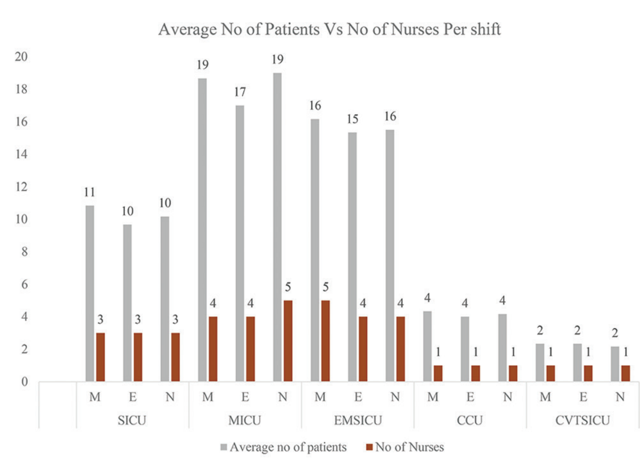

Figure 1: Comparison of average number of patients and nurses in each shift in all intensive care units

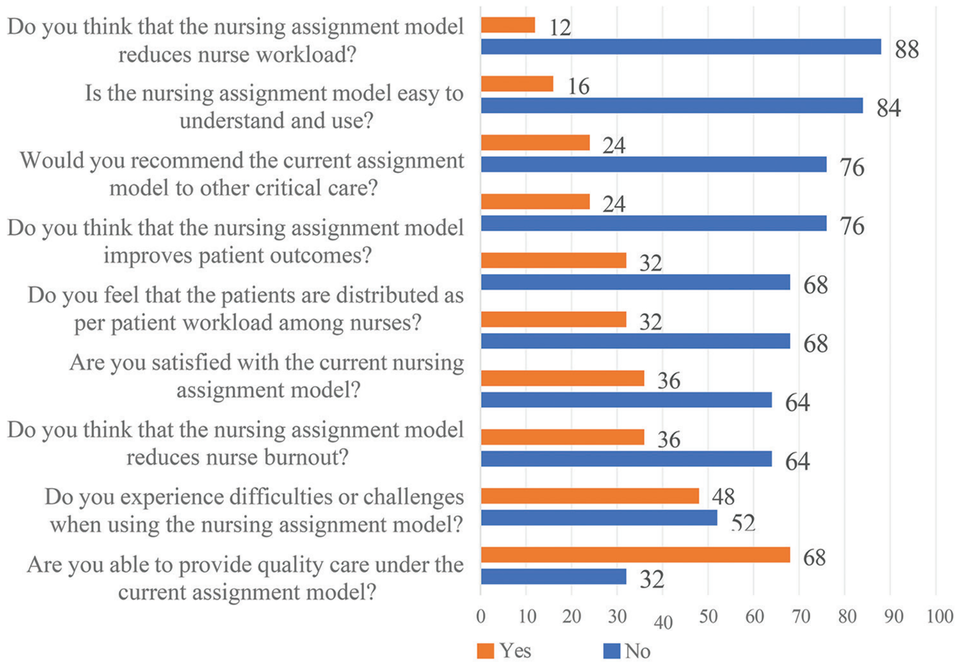

Figure 2: Perception of nurse's satisfaction on patient assignment model

[CVTSICU]). MICU and EMSICU have the heaviest loads, with 15–19 patients and only 4–5 nurses per shift. SICU averages 10–11 patients with 3 nurses, CCU maintains about four patients per nurse, and CVTSICU is best staffed at 2 patients per nurse. The figure highlights workload imbalances and staffing adequacy differences among units.

Figure 2 shows nurses' satisfaction with the patient assignment model. Most nurses viewed it positively – 88% found it effective, 84% easy to follow, and 76% felt workloads were fair. About 68% believed patients were safe and reported overall satisfaction, while 36% faced difficulties, and 48% felt limited in providing quality care. Leadership support was noted by 68%, indicating strong organizational backing but room for improvement.

Table 1 summarizes patient outcomes across ICUs. Infections were common in SICU, MICU, and EMSICU but absent in CVTSICU and CCU. Surgical site infections and mortality were highest in EMSICU and MICU, while CCU showed the most comorbidities (80%) and best recovery (80%), followed by CVTSICU (66.7%). MICU and EMSICU had lower recovery rates and higher readmissions.

Table 2 presents mean TISS scores across ICUs over 6 days, indicating care intensity. MICU (8.91±5.34) and EMSICU (8.05±5.67) had the highest scores, followed by SICU (7.31±5.76), reflecting higher care demands. CVTSICU (2.66±1.66) and CCU (0.8±0.75) showed lower scores, indicating less critical care needs.

Table 3 shows average TISS scores for activities across ICUs, indicating intervention levels. Basic activities were highest in all units, especially MICU (17.83±0.75) and EMSICU (16.67±1.03). Cardiovascular, ventilator, and renal supports

Table 1: Distribution of patient outcomes in each ICUs n=58

Patients outcomes	SICU		MICU		EMSICU		CVTSICU		CCU	
	n=12		n=20		n=18		n=3		n=5	
	f	%	f	%	f	%	f	%	f	%
CAUTI	3	25.0	6	30.0	4	22.2	0	0.0	0	0.0
CLABSI	2	16.7	2	10.0	4	22.2	0	0.0	0	0.0
Pressure injuries	5	41.7	7	35.0	5	27.8	0	0.0	0	0.0
VAP	5	41.7	7	35.0	6	33.3	0	0.0	0	0.0
Surgical site infections	3	25.0	6	30.0	7	38.9	2	66.7	1	20.0
Mortality	3	25.0	8	40.0	8	44.4	1	33.3	0	0.0
Readmission	2	16.7	5	25.0	4	22.2	1	33.3	1	20.0
Comorbidities	4	33.3	7	35.0	6	33.3	1	33.3	4	80.0
Complete recovery	5	41.7	9	45.0	6	33.3	2	66.7	4	80.0

CAUTI: Catheter-associated urinary tract infection, CLABSI Central line-associated bloodstream infection, VAP: Ventilator-associated pneumonia, SICU: Surgical intensive care unit, MICU: Medical intensive care unit, CCU: Coronary care unit, EMSICU: Emergency medical surgical intensive care unit, CVTSICU: Cardio vascular thoracic surgery intensive care unit

Table 2: Mean TISS score category wise of all ICUs (6 days) in critical care units

Area	Overall TISS score
	M±SD
SICU	7.31±5.76
MICU	8.91±5.34
EMSICU	8.05±5.67
CVTSICU	2.66±1.66
CCU	0.8±0.75

M: Mean, SD: Standard deviation TISS: Therapeutic intervention scoring system, ICU: intensive care unit, SICU: Surgical intensive care unit, MICU: Medical intensive care unit, CCU: Coronary care unit, EMSICU: Emergency medical surgical intensive care unit, CVTSICU: Cardio vascular thoracic surgery intensive care unit

Table 3: Average TISS score of all activities

Activities	Max score	SICU	MICU	EMSICU	CVTSICU	CCU
		M±SD	M±SD	M±SD	M±SD	M±SD
Basic activities	10	10.67±1.21	17.83±0.75	16.67±1.0328	3±0	5±0
Cardiovascular Support	5.33	5.33±0.51	9.67±1.03	6.5±0.54	0.33±0.51	0
Specific interventions	5.33	5.33±0.51	9.67±1.03	6.5±0.54	3±0	0
Ventilator support	5.33	5.33±0.51	9.67±1.03	6.5±0.54	0	0
Renal support	10.5	10.5±1.04	18.67±1.21	16.17±1.16	3±0	0.33±0.5
Neurologic support	0	0	0	0.33±0.81	0	0
Metabolic support	7.5	7.5±1.87	9.67±1.03	8.33±3.14	0	0

M: Mean, SD: Standard deviation, TISS: Therapeutic intervention scoring system, SICU: Surgical intensive care unit, MICU: Medical intensive care unit, CCU: Coronary care unit, EMSICU: Emergency medical surgical intensive care unit, CVTSICU: Cardio vascular thoracic surgery intensive care unit

Table 4: Categories of TISS score in each ICU *n*=58

TISS classification	SICU (*n*=12)		MICU (*n*=20)		EMSICU (*n*=18)		CVTSICU (*n*=3)		CCU (*n*=5)	
	f	%	*f*	%	*f*	%	*f*	%	*f*	%
Class I (0–19) Physiological stable	6	50	8	40	11	61.1	2	66.7	5	100
Class II (20–34) Physiological stable but require ICUs and close monitoring	0	0	0	0	1	5.6	1	33.3	0	0
Class II (35–60) Hemodynamically severe and unstable	0	0	0	60	6	33.3	0	0	0	0
Class II (>60) Patients need continuous and specialized medical surgical assistance	0	0	0	0	0	0	0	0	0	0

TISS: Therapeutic intervention scoring system, SICU: Surgical intensive care unit, MICU: Medical intensive care unit, CCU: Coronary care unit, ICU: Intensive care unit, EMSICU: Emergency medical surgical intensive care unit, CVTSICU: Cardio vascular thoracic surgery intensive care unit

were more frequent in these units, while CVTSICU and CCU had minimal needs. Overall, MICU and EMSICU required the most intensive care, whereas CVTSICU and CCU involved fewer interventions.

Table 4 indicates that the majority of patients in SICU and MICU were classified as Class I and III, each accounting for 50%. In EMSICU, 61.1% belonged to Class I, while 33.3% were in Class III. CVTSICU had 66.7% in Class I and 33.3% in Class II. All CCU patients (100%) were in Class I. No patients were recorded in Class IV across any ICU.

Table 5 shows that in Class I, only CVTSICU (18.33) and CCU (11.6) had TISS scores, while SICU, MICU, and EMSICU scored 0. In Class II, SICU (29.5), MICU (30.22), and EMSICU (25.17) recorded scores, with none for CVTSICU and CCU. No scores were observed for Classes III and IV in any unit.

Table 6 shows the mean time spent on nursing care in ICUs. Ventilated patient care required the most time – 458 min (7.6 h) in the morning versus 278 min (5 h) in evening and night shifts. Non-ventilated care took 400 min (6.6 h) in the morning and 150 min (3 h) later. ICU management activities averaged 450 min (7.5 h). Overall, morning shifts had the highest workload.

Table 7 compares Round 2 and Round 3 activity scores. The mean increased from 42.60 to 51.88, and the median from 43.00 to 52.00, indicating improved consensus among participants. The Wilcoxon signed-rank test (Z = 4.172, $P < 0.001$) shows a statistically significant difference between the two rounds.

Table 5: Average TISS Score of all ICU *n*=58

TISS classification	SICU	MICU	EMSICU	CVTSICU	CCU
Class I (0–19) Physiological stable	0	0	0	18.33	11.6
Class II (20–34) Physiological stable but require ICUs and close monitoring	29.5	30.22	25.17	0	0
Class II (35–60) Hemodynamically severe and unstable	0	0	0	0	0
Class II (>60) Patients need continuous and specialized medical-surgical assistance	0	0	0	0	0

TISS: Therapeutic intervention scoring system, SICU: Surgical intensive care unit, MICU: Medical intensive care unit, CCU: Coronary care unit, ICU: Intensive care unit, EMSICU: Emergency medical surgical intensive care unit, CVTSICU: Cardio vascular thoracic surgery intensive care unit

Table 6: Distribution of mean time in minutes and hours for nursing care activities based on three Delphi rounds

Nursing activities	Mean time in minutes	Mean time in hours
Nursing care activities for ventilated patients- Morning	458	7.6
Nursing care activities for ventilated patients- Evening and night	278	5
Nursing care activities for non-ventilated patients- Morning	400	6.6
Nursing care activities for non-ventilated patients- Evening and night	150	3
ICU management activities	450	7.5

ICU: Intensive care unit

Table 7: Comparison between round 2 and round 3 activities

Rounds	*n*	Mean	Median	Standard deviation	Wilcoxon Singed-rank test	*P*-value
Round 2	25	42.60	43.00	5.69	4.172**	<0.001
Round 3	25	51.88	52.00	0.33		

**Indicates statistical significance at the $p < 0.01$ level based on the Wilcoxon signed-rank test.

Table 8 Correlate between Round 2 and Round 3 activities, measured using Kendall's tau b, was −0.220 with a *P*-value of 0.207. This negative correlation is weak and statistically non-significant at the 5% level, indicating that changes in Round 2 activities did not meaningfully influence Round 3 outcomes.

Table 9 presents the validated patient acuity-based nursing assignment model developed using the Delphi technique. Integrating TISS scores with nursing care hours, it ensures equitable workload distribution. The required nurses per 24 hours were: SICU – 23, MICU – 38, EMSICU – 34, CVTSICU – 4, and CCU – 8, supporting efficient, quality care.

Figure 3 shows nurse engagement in evaluating the nursing activity model. Most participated in assessing time allocation for patient complexity (25) and accuracy of time estimates (24), followed by ensuring high-acuity care (23) and inclusion of essential activities with realistic timings (22).

Discussion

In critical care units, patients vary widely in illness severity and care needs. A patient acuity-based nursing assignment model ensures that staffing reflects the complexity and intensity of patient conditions rather than simple patient counts.

This study addressed ongoing concerns that traditional nurse–patient assignments often fail to match nursing competencies with patient complexity, resulting in workload imbalances, decreased care quality, and nurse dissatisfaction. Consistent with previous findings by Aiken *et al*. and Needleman *et al.*[12,13] This study confirms that staffing based solely on patient numbers is inadequate in high-intensity settings such as ICUs. These authors emphasized that mismatched workloads and poor skill mix contribute to adverse outcomes and reduced patient safety.

The current research developed and validated a patient acuity-based assignment model that integrates nursing qualifications, patient severity scores, and real-time care demands. Aligned with the frameworks proposed by Havaei and MacPhee,[14] the model demonstrated clinical feasibility, reliability, and applicability. It enhanced workload balance, minimized subjective bias, and improved assignment appropriateness, findings supported by Twigg *et al*. and Carayon and Gurses,[15] who found that evidence-based staffing models improve staff performance and patient outcomes.

The majority of participants were female and moderately experienced, with limited representation from senior nurses – reflecting the demographic trends noted by Aiken *et al*. Although nurses described assignments as structured and manageable, only half reported being able to deliver quality

Table 8: Correlate between round 2 and round 3 activities

Round	Kendall's tau_b	*P*-value	Sig. at 5% level
Round 2 versus Round 3	−0.220	0.207	NS

Table 9: Final patient acuity-based nursing assignments model for all critical care units based on patient classification by TISS score and time taken nursing activities by Delphi experts

1. SICU			
Category of patients	Nursing care hours/shift		
	Morning	Evening	Night
Class I pts	6 pts*6 h=36 h	6 pts*3 h=18 h	6 pts*3h=18 h
Class III Pts	6 pts*7 h=42 h	6 pts*5 h=30 h	6 pts*5 h=30 h
Total NCH	78 h	48 h	48 h
Total=78+48+48=174 h			
Actual working hours rendered by each nursing personnel per shift per day			
Shift	Duty hours	Nurses/shift	
Morning	7 h	78 h/7h	11
Evening	7 h	48 h/7 h	7
Night	10 h	48 h/10h	5
		Total nurses	23 nurses
2. MICU			
Category of patients	Nursing care hours/shift		
	Morning	Evening	Night
Class I pts	8 pts*6 h=48 h	8 pts*3 h=24 h	8 pts*3h=24 h
Class III Pts	12 pts*7 h=84 h	12 pts*5 h=60 h	12 pts*5 h=60 h
Total NCH	132 h	84 h	84 h
Total=132+84+84=300 h			
Actual working hours rendered by each nursing personnel per shift per day			
Shift	Duty hours	Nurses/shift	
Morning	7 h	132 h/7 h	18
Evening	7 h	84 h/7 h	12
Night	10 h	84 h/10 h	8
		Total nurses	38 nurses
3. EMSICU			
NCH needed by patients at each Level of care per day			
Category of patients	NCH/shift		
	Morning	Evening	Night
Class I pts	11 pts*6 h=66 h	11 pts* 3 h=33 h	11 pts*3 h=33 h
Class III Pts	7 pts*7 h=49 h	7 pts*5 h=35 h	7 pts*5 h=35 h
Total NCH	115 h	68 h	68 h
Total=115+68+68=251 h			
Actual working hours rendered by each nursing personnel per shift per day			
Shift	Duty hours	Nurses/shift	
Morning	7 h	115 h/7h	16
Evening	7 h	68 h/7h	9
Night	10 h	68 h/10h	9
		Total nurses	34 nurses

(Contd...)

Table 9: *(Continued)*

4. CVTSICU			
Number of NCH needed by patients at each Level of care per day			
Category of patients	**NCH/shift**		
	Morning	**Evening**	**Night**
Class I pts	2 pts*6 h=12 h	2 pts*3 h=6 h	Pts*3 h=6 h
Class III Pts	1 pts*7 h=7 h	1 pt*5 h=5 h	1 pt*5 h=5 h
Total NCH	19 h	11 h	11 h
Total=19+11+11=41 h			
Actual working hours rendered by each nursing personnel per shift per day			
Shift	**Duty hours**	**Nurses/shift**	
Morning	7 h	19 h/7 h	2
Evening	7 h	11 h/7 h	1
Night	10 h	11 h/10 h	1
		Total nurses	4 nurses
5. CCU			
Number of NCH needed by patients at each Level of care per day			
Category of patients	**NCH/shift**		
	Morning	**Evening**	**Night**
Class I pts	5 pts*6 h=30 h	5 pts*3 h=15 h	5 pts*3 h=15 h
Total NCH	30 h	15 h	15 h
Total=30+15+15=60 h			
Actual working hours rendered by each nursing personnel per shift per day			
Shift	**Duty hours**	**Nurses/shift**	
Morning	7 h	30 h/7h	4
Evening	7 h	15 h/7h	2
Night	10 h	15 h/10h	2
		Total nurses	8 nurses
Total nurses required on duty per 24 h in CCU=8 nurses			

Total nurses required on duty per 24 h in SICU=23. Total nurses required on duty per 24 h in MICU=38 nurses. Total nurses required on duty per 24 h in EMS ICU=34 nurses. Total nurses required on duty per 24 h in CVTS ICU=4 nurses. NCH: Nursing care hours, TISS: Therapeutic intervention scoring system

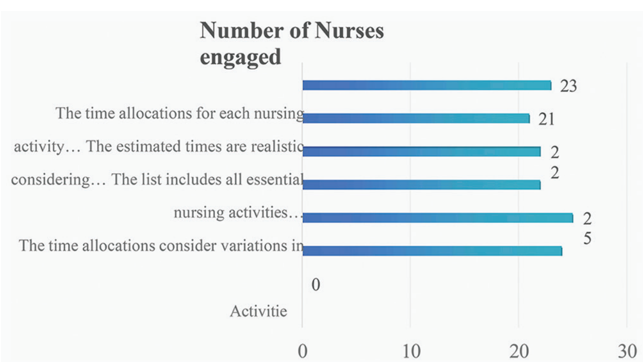

Figure 3: Feedback form for Delphi experts on the final patient acuity-based assignments model

care, largely due to weak leadership support. This observation aligns with Laschinger *et al*.[16] and Twigg *et al*.,[17] who linked ineffective staffing structures and poor leadership to higher burnout and job dissatisfaction.

Mortality and complication rates were highest in the MICU and EMSICU, whereas the CCU showed no mortality but higher comorbidity rates, indicating a mismatch between patient severity and staff allocation. These findings are consistent with Needleman *et al*. and Aiken *et al*., who demonstrated that inadequate staffing in high-acuity environments correlates with increased adverse events.

Overall, this study reinforces the importance of data-driven and equitable nursing assignment models. By bridging the gap between conceptual frameworks and clinical realities, the acuity-based model contributes practical implications for nursing management, education, and policy. Ongoing refinement, integration with electronic health records, and continuous evaluation will further enhance its effectiveness and sustainability in critical care settings.

Conclusion

The new acuity-based nursing assignment plan for critical care units aligns nursing time and skills with patients' actual needs using clear scoring. Experts found it reliable, practical, and effective in enhancing safety and efficiency. It can reduce burnout, boost job satisfaction, and improve patient outcomes by ensuring fair workload distribution. Continued refinement, integration with electronic health records, and testing across ICUs will support its long-term success.

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Conflicts of Interest

There are no conflicts of interest.

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