DOI: 10.7860/IJNMR/2025/79468.2464

Original Article

Paediatrics Section

Validity of the SNAP-II Score in Predicting Neonatal Mortality and Morbidity at a Tertiary Care NICU: A Prospective Observational Study

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ABSTRACT

Introduction: The Neonatal Mortality Rate (NMR) remains high in India despite various advances in neonatal care. A reliable scoring system may help identify sick neonates and facilitate early interventions. The Score for Neonatal Acute Physiology (SNAP)-II scoring system was developed to assess the severity of illness and predict mortality and morbidity among neonates admitted to the Neonatal Intensive Care Unit (NICU).

Aim: To validate the SNAP-II scoring system in predicting neonatal outcomes at a tertiary care NICU in Uttar Pradesh.

Materials and Methods: A prospective observational study was conducted in the NICU of the Department of Paediatrics at FH Medical College and Hospital, Agra-Etmadpur, Uttar Pradesh, India. A total of 259 neonates aged between 1 and 28 days, who were admitted to the NICU between September 2022 and March 2024, were included in the study after obtaining consent from parents. Physiological parameters were recorded within 12 hours of admission to calculate SNAP-II scores. Neonatal outcomes, including mortality, need for respiratory support, inotropic use, and length of stay in the NICU, were analysed. Statistical analysis included t-tests, chi-square tests, Receiver Operating Characteristics (ROC) curves, and sensitivity-specificity assessments.

Results: A total of 259 babies were enrolled, but 32 were excluded from the study (9 expired within 24 hours, and 23 left against medical advice). In the remaining 227 babies, there were 146 (64.3%) males and 81 (35.7%) were females. Most of the babies were preterm 120 (52.9%), while 107 (47.1%) were term. The study found a significant association between higher SNAP-II scores and increased mortality, prolonged NICU stay, and a greater need for respiratory support and inotropes ($p<0.001$). A SNAP-II cut-off of 46 showed 93.3% sensitivity and 89% specificity for predicting mortality. Individual parameters of SNAP-II did not independently predict outcomes.

Conclusion: The SNAP-II scoring system is a reliable tool for early risk stratification in NICUs, facilitating targeted interventions and optimising resources. Its integration into NICU protocols can significantly improve neonatal outcomes.

Keywords: Acute physiological score, Neonatal intensive care unit, Outcome, Respiratory support, Risk stratification, Score for neonatal acute physiology

INTRODUCTION

Neonatal mortality remains a major global health concern, especially in low- and middle-income countries like India. The current NMR in India is 25 per 1,000 live births, significantly higher than in developed nations, where the NMR is often in single digits [1]. Uttar Pradesh, one of India's most populous states, reports an even higher NMR of 35 per 1,000 live births, reflecting considerable regional disparities and the need for targeted interventions [1].

Neonatal mortality, defined as death within the first 28 days of life, is predominantly caused by preventable conditions such as infections, prematurity, and birth asphyxia [2,3]. Addressing these challenges requires robust quality control measures in Neonatal Intensive Care Units (NICUs) to improve outcomes and optimise resource allocation [4].

Illness severity scoring systems have emerged as essential tools for predicting neonatal morbidity and mortality in NICUs. These systems enable clinicians to identify high-risk neonates, facilitate early interventions, and improve prognostic accuracy [5]. Historically, parameters such as birth weight, gestational age, and Appearance, Pulse, Grimace, Activity, and Respiration (APGAR) scores have been the primary predictors of neonatal outcomes. However, their limitations in prognostic precision necessitated the development of more objective scoring tools [6].

One of the most widely used systems for assessing neonatal illness severity is the Score for Neonatal Acute Physiology (SNAP), initially developed in North America. SNAP was among the first tools to provide an objective measure of neonatal illness severity and predict outcomes; however, its complexity limited its practicality [5]. To address these issues, Richardson DK et al., introduced the SNAP-II score in 2001. This simplified version reduced the number of parameters to six: Mean Blood Pressure (MBP), urine output, Partial pressure of arterial oxygen to the Fraction of inspired oxygen ($PaO2/FiO2$) ratio, serum pH, presence of multiple seizures, and lowest temperature. It also shortened the observation period to 12 hours, enhancing its clinical utility and efficiency [7].

Several studies have validated the predictive ability of the SNAP-II score for neonatal morbidity and mortality [8,9]. Research in both developed and resource-limited settings has demonstrated its reliability in identifying critically ill neonates and guiding clinical decisions [8-10]. For example, a study in Nepal highlighted its effectiveness in resource-constrained NICUs [11], while other studies confirmed its role in predicting neonatal mortality and morbidities, including structural brain disorders [12,13].

Given the high NMR in Uttar Pradesh and the significant burden on tertiary NICUs catering to sick neonates from peripheral regions, this study was conducted to validate the SNAP-II scoring system for predicting neonatal outcomes in a tertiary care NICU in Uttar

Pradesh. By assessing its accuracy in predicting neonatal mortality and morbidity, the study aimed to optimise care strategies, enabling early identification of high-risk neonates and improving overall outcomes.

MATERIALS AND METHODS

The prospective observational study was conducted in the NICU of the Department of Paediatrics at FH Medical College and Hospital, Agra-Etmadpur, Uttar Pradesh, India. between September 2022 and March 2024. All newborns were enrolled in the study after obtaining informed consent from their parents. The hospital's Ethical Committee approved present study (Reference No: FHMC/IEC/R. Cell/2022/19).

Inclusion criteria: All neonates aged 1 to 28 days admitted to the NICU during the study period were included.

Exclusion criteria: Neonates with a stay of less than 24 hours, congenital malformations deemed incompatible with life, those born at less than 26 weeks of gestation, and cases where consent was not provided by parents or guardians were excluded.

Sample size calculation: Sample size estimation was performed using nMaster 2.0 (CMC, Vellore). A minimum sample size of 157 was calculated to be sufficient for a power of 80%, at a precision level of 5% with an expected proportion of 0.60 [14]. However, all neonates admitted to the NICU meeting the inclusion criteria were included in the study (n=259) to achieve higher accuracy.

Formula:

$$n = \frac{Z^2 1-\alpha/2\ p\ (1-p)}{d^2}$$

Where, p: expected proportion, d: absolute precision, 1-α/2: desired confidence level.

Study Procedure

Data collection: After the enrollment of all neonates, the SNAP-II score was calculated. Neonatal outcomes, including mortality, respiratory support, inotrope use, and NICU length of stay, were analysed. The worst recorded values for each parameter were scored, with the SNAP-II score ranging from 0 (best) to 115 (worst) [8]. Neonates were followed until discharge for outcome evaluation.

SNAP-II scoring: Physiological data required for SNAP-II scoring were collected within the first 12 hours of NICU admission. SNAP-II scores were based on six parameters:

1. **Mean blood pressure:** Non invasive Blood Pressure (BP) monitoring was conducted every two hours using an appropriate neonatal cuff, with the lowest Mean Blood Pressure (MBP) recorded.
2. **Body temperature:** Measured using a skin probe attached to a radiant warmer, with the lowest reading recorded.
3. **Serum pH:** Determined via Arterial Blood Gas (ABG) analysis using ABL80 Flex; the lowest value was used for scoring.
4. **PaO_2/FiO_2 ratio:** Calculated using ABG results and the oxygen delivery mode (room air, oxygen prongs, Continuous Positive Airway Pressure (CPAP), or Mechanical Ventilation (MV)).
5. **Urine output:** Measured every six hours via diaper weight, collection bags, or catheterisation; the lowest value was recorded.
6. **Multiple seizures:** Documentation was based on the number of seizures during the 12-hour period.

STATISTICAL ANALYSIS

Data were analysed using Statistical Packages for Social Sciences (SPSS) version 27.0. Descriptive statistics summarised variables, and the Shapiro-Wilk test assessed normality. Independent t-tests and Chi-square tests were applied where appropriate. Sensitivity, specificity, and ROC curves were computed for the predictive analysis of SNAP-II scores. Statistical significance was set at ($p<0.05$).

RESULTS

A total of 259 babies were enrolled, with 32 excluded from the study (9 expired within 24 hours, and 23 left against medical advice). Thus, a total of 227 babies were included in the study, comprising 146 (64.3%) males and 81 (35.7%) females. Of these, 120 (52.9%) were preterm babies, and 107 (47.1%) were term babies [Table/Fig-1].

Particulars	n (%)
Gender	
Female	81 (35.7%)
Male	146 (64.3%)
Gestational age	
Less than 37 weeks	120 (52.9%)
37 weeks or more	107 (47.1%)
Total	227 (100%)

[Table/Fig-1]: Demographic profile.

Applying the SNAP-II score to the enrolled neonates showed that as the SNAP-II score increased, mortality also increased, which was statistically significant (p=0.001) [Table/Fig-2]. When the score was applied to neonates with respiratory system involvement, the findings indicated that among the 69 neonates assessed with scores between 0-15, 24 (34.8%) required CPAP, 22 (31.9%) required oxygen, 16 (23.2%) needed MV, and only 7 (10.1%) remained on room air. Although this group included just one neonate with scores ranging from 61-75, that baby required MV (100%).

SNAP-II score	Outcome		Total
	Survived	Expired	
0-15	69 (100.0%)	0	69 (100%)
16-30	51 (100.0%)	0	51 (100%)
31-45	34 (91.9%)	3 (8.1%)	37 (100%)
46-60	27 (81.8%)	6 (18.2%)	33 (100%)
61-75	1 (4.8%)	20 (95.2%)	21 (100%)
76 or more	0	16 (100%)	16 (100%)
Total	182 (80.2%)	45 (19.8%)	227 (100%)

[Table/Fig-2]: Distribution of neonatal outcomes based on SNAP-II score.
p-value: 0.001*; significant; Values presented as n (%)

The need for MV increased with higher SNAP-II scores, while minimal support such as room air or oxygen was more common in lower score ranges, emphasising the severity of illness at higher scores. The requirement for the type of assisted ventilation was compared across SNAP-II scores using the Chi-square test; however, the difference was found to be non significant [Table/Fig-3].

Comparing individual parameters of the score with mean values revealed no statistically significant differences (p>0.05). These findings suggest that while higher scores may correlate with outcomes, individual parameters alone may not be definitive predictors of mortality [Table/Fig-4].

Type of respiratory support	SNAP-II score					
	0-15	16-30	31-45	46-60	61-75	Total
Room air	7 (10.1%)	2 (3.9%)	3 (8.8%)	3 (11.1%)	0 (0%)	15 (8.3%)
Oxygen	22 (31.9%)	7 (13.7%)	5 (14.7%)	1 (3.7%)	0 (0%)	35 (19.2%)
CPAP	24 (34.8%)	16 (31.4%)	12 (35.3%)	8 (29.6%)	0 (0%)	60 (32.9%)
MV	16 (23.2%)	26 (51%)	14 (41.2%)	15 (55.6%)	1 (100%)	72 (39.6%)
Total	69 (100%)	51 (100%)	34 (100%)	27 (100%)	1 (100%)	182 (100%)

[Table/Fig-3]: Distribution of respiratory support modes with different SNAP-II score ranges.
p-value: 0.744; Non significant; CPAP: Continuous positive airway pressure; MV: Mechanical ventilation

Parameters		n	Mean±SD	Std. error	Minimum	Maximum	p-value
Temperature (in degree celsius)	Survived	182	34.01±1.69	0.13	27.90	38.70	0.656
	Expired	45	34.14±1.89	0.28	27.40	37.90	
NIBP (in millimetre of mercury)	Survived	182	34.79±14.61	1.08	0.00	72.00	0.177
	Expired	45	38.11±15.29	2.28	0.00	72.00	
pH	Survived	182	7.18±0.13	0.01	6.74	7.43	0.232
	Expired	45	7.20±0.14	0.02	6.85	7.44	
PaO_2/FiO_2	Survived	182	2.21±1.10	0.08	0	4.51	0.534
	Expired	45	2.32±1.06	0.16	0	4.12	
Urine output (in mL per kg per hour)	Survived	182	1.84±1.19	0.09	0	5.30	0.409
	Expired	45	2.00±0.94	0.14	0.30	3.90	
Seizures	Yes	77	-	-	-	-	
	No	150	-	-	-	-	

[Table/Fig-4]: Comparative analysis of physiological parameters and the incidence of seizures among survived and expired neonates in a NICU setting (N=227).

Duration of NICU stay	SNAP-II score					
	0-15	16-30	31-45	46-60	61-75	Total
0 -2	69 (100%)	37 (72.5%)	5 (14.7%)	0 (0.0%)	0 (0.0%)	111 (61.0%)
3-5	0 (0.0%)	13 (25.5%)	20 (58.8%)	11 (40.7%)	0 (0.0%)	44 (24.2%)
6-8	0 (0.0%)	1 (2.0%)	8 (23.5%)	6 (22.2%)	0 (0.0%)	15 (8.2%)
9-11	0 (0.0%)	0 (0.0%)	1 (2.9%)	5 (18.5%)	0 (0.0%)	6 (3.3%)
12 or more	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (18.5%)	1 (100.0%)	6 (3.3%)
Total	69 (37.9%)	51 (28.0%)	34 (18.7%)	27 (14.8%)	1 (0.5%)	182 (100.0%)

[Table/Fig-5]: NICU stay (in days) across different SNAP-II score.
p-value: 0.001*; significant; Values presented as n (%)

Number of inotropes			SNAP II scores						Total
			0-15	16-30	31-45	46-60	61-75	76 or more	
Inotropes	0	N (%)	69 (100%)	32 (62.7%)	14 (37.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	115 (50.6%)
	1	N (%)	0 (0.0%)	19 (37.3%)	15 (40.5%)	11 (33.3%)	0 (0.0%)	0 (0.0%)	45 (19.8%)
	2	N (%)	0 (0.0%)	0 (0.0%)	5 (13.5%)	12 (36.4%)	0 (0.0%)	0 (0.0%)	17 (7.5%)
	3	N (%)	0 (0.0%)	0 (0.0%)	3 (8.1%)	10 (30.3%)	21 (100%)	16 (100%)	50 (22.0%)
Total		N (%)	69 (100%)	51 (100%)	37 (100%)	33 (100%)	21 (100%)	16 (100%)	227 (100%)

[Table/Fig-6]: Association between SNAP-II scores and the number of inotropes required by neonates.
p-value: 0.001*, significant; Values presented as n (%)

Higher SNAP-II scores were associated with prolonged NICU stays, with the majority of patients requiring extended care beyond six days at scores above 45, which was highly significant [Table/Fig-5]. As SNAP-II scores increased, the need for inotropes rose, with the majority of patients requiring three inotropes found in the highest SNAP-II score ranges (p=0.001) [Table/Fig-6]. Sensitivity was high at lower percentiles but decreased as the percentiles increased. In contrast, the Positive Predictive Value (PPV) and specificity improved as the percentiles rose, while the Negative Predictive Value (NPV) remained high across all percentiles [Table/Fig-7,8].

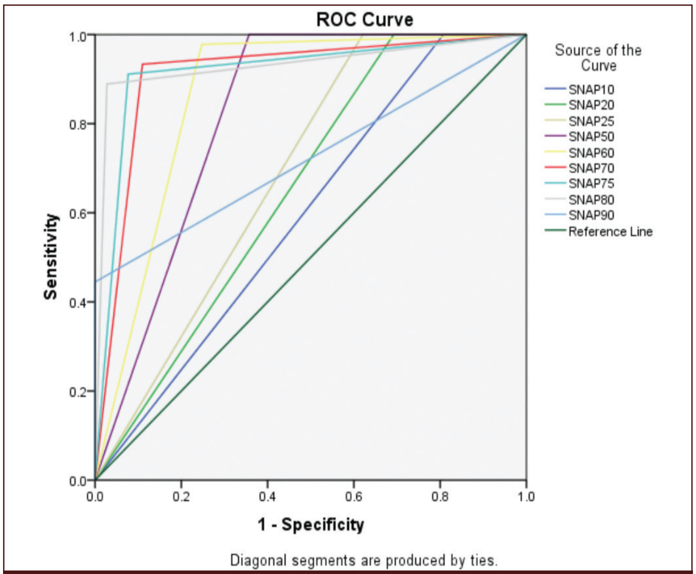
DISCUSSION

Neonatal deaths account for approximately 45% of under-five mortality worldwide, underscoring their global significance [15]. In Uttar Pradesh, the most populated state of India, neonatal mortality remains high despite advancements in treatment [1,15]. Scoring systems like SNAP-II have become essential in NICUs, providing objective measures of illness severity, predicting outcomes, and aiding in efficient resource allocation.

In present study, 227 neonates were evaluated. A male predominance (64.3%) was noted, likely reflecting gender-biased healthcare-seeking behaviours in rural areas. Similar male

Percentile	Cut-off point	Sensitivity	Specificity	PPV	NPV
At 10th percentile	8	100%	19.2%	23.4%	100%
At 20th percentile	13	100%	30.8%	26.3%	100%
At 25th percentile	15	100%	37.9%	28.5%	100%
At 50th percentile	27	100%	64.3%	40.9%	100%
At 60th percentile	36	97.8%	75.3%	49.4%	99.3%
At 70th percentile	46	93.3%	89%	67.7%	98.2%
At 75th percentile	48	91.1%	92.3%	74.5%	97.7%
At 80th percentile	56.4	88.9%	97.3%	88.9%	97.3%
At 90th percentile	69	44.4%	100%	100%	87.9%

[Table/Fig-7]: Diagnostic performance of the SNAP-II score at different percentiles in predicting neonatal outcomes.



[Table/Fig-8]: Shows Area under Curve (AUC) values progressively increase from SNAP 10 to SNAP 80, peaking at SNAP 80 (AUC=0.931), indicating excellent discriminative ability.

predominance was reported by Shah L et al., (63.07%), Shrestha D et al., (62.8%), Somalika P et al., (56%), and Verma AA et al., (52.2%) [9,10,4,6].

Preterm neonates accounted for 52.8% of admissions, comparable to Somalika P et al., (48%) [14], but differing from Shah L et al., (34.2%) and Ashrafzadeh M et al., (41.3%) [9,16]. The high preterm rates in present study are attributed to inadequate antenatal care and unbooked pregnancies from peripheral areas.

Birth weight analysis showed that 46.2% of neonates had normal weight, consistent with Shah L et al., (50.75%) [9]. Vaginal delivery (57.7%) was the predominant mode, aligning with findings from Shah L et al., (66.54%), Aggarwal A et al., (60%), and Tanigasalam V et al., (60.8%) [9,17,18]. The overall mortality rate was 18.9%, similar to Somalika P et al., (16%) and Afjeii et al., (17%) [14,19]. However, higher mortality was observed in studies by Mesquita Ramirez MN et al., (62.5%), likely due to sicker neonates with higher SNAP-II scores [20].

A SNAP-II cut-off score of 46 predicted mortality with 93.3% sensitivity and 89% specificity, consistent with Somalika P et al., (99.99% sensitivity, 97.62% specificity at a cut-off of 44) and Mesquita Ramirez MN et al., (60% sensitivity, 86.6% specificity at a cut-off of 40) [14,20]. Muktan D et al., found that a SNAP-II score ≥38 predicted mortality with 84.4% sensitivity and 91% specificity [21]. These findings validate the robust predictive capability of SNAP-II scores.

In the current study, a significant association was found between SNAP-II scores and NICU length of stay ($p<0.001$). Thus, the progression of disease, the rapidity of deterioration, and death can be predicted by SNAP-II scores. Somalika P et al., found a similar association between SNAP-II scores and length of stay [14]. In contrast, Muktan D et al., and Lim L et al., reported no correlation between SNAP-II scores and NICU stay, although they observed associations with Score for Neonatal Acute Physiology with Perinatal Extension-II (SNAPPE-II) scores [21,22].

Additionally, higher SNAP-II scores correlated with prolonged assisted ventilation. The requirement for the type of assisted ventilation was compared across SNAP-II scores using the Chi-square test. The difference was found to be non significant, similar to findings by Verma AA et al., [13]. The requirement for inotropes also increased with higher SNAP-II scores, a significant finding, as no prior studies have reported such an association. Type of respiratory support is not associated with SNAP-II scores, while inotropic support has significant implications in the present study.

The individual parameters of SNAP-II, such as low mean arterial pressure, lowest blood pH, and urine output, were not statistically significant predictors in present study. This contrasts with Mesquita Ramirez MN et al., who found these parameters significantly associated with mortality [20]. Overall, the findings underscore SNAP-II's utility as a comprehensive and reliable predictor of neonatal outcomes, supporting its use in NICU settings for early risk stratification and optimal resource allocation. Further, studies are needed to validate associations with inotrope use and ventilation duration.

Limitation(s)

The SNAP-II scoring system has certain limitations that must be acknowledged. It relies solely on clinical and physiological parameters recorded within the first 12 hours of life, which may not adequately capture the evolving severity of illness over time or complications such as hospital-acquired sepsis. Additionally, SNAP-II does not account for gestational age or birth weight, which are critical determinants of neonatal outcomes. This is particularly relevant for preterm and Extremely Low Birth Weight (ELBW) or Very Low Birth Weight (VLBW) infants, who often require prolonged hospital stays for feeding and weight gain.

CONCLUSION(S)

In conclusion, the SNAP-II scoring system is a reliable and efficient tool for predicting morbidity and mortality in NICUs. The present study demonstrated that neonates with higher SNAP-II scores were at a significantly increased risk of mortality and morbidity, as reflected in prolonged NICU stays, extended durations of assisted ventilation, and increased requirements for inotropes. The scoring system provides a valuable framework for triaging critically ill neonates, enabling early interventions and better resource allocation. Its high specificity and sensitivity make SNAP-II particularly useful in NICUs catering to outborn neonates, where the burden of critical illness is higher. The routine implementation of SNAP-II scoring in NICU protocols can enhance early risk identification and improve neonatal outcomes. High-score neonates should be closely monitored with proactive interventions to minimise complications. Further validation studies are needed to confirm its association with prolonged ventilation and inotrope requirements.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Apr 06, 2025
- Manual Googling: Aug 22, 2025
- iThenticate Software: Aug 27, 2025 (10%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Mar 21, 2025**
Date of Peer Review: **Jun 10, 2025**
Date of Acceptance: **Aug 28, 2025**
Date of Publishing: **Dec 31, 2025**