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Original Research Article

ASSESSING THE UTILITY OF MSNS IN PREDICTING MORTALITY OUTCOMES AMONG OUTBORN NEONATES

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ABSTRACT

Background: Neonatal mortality remains a significant public health challenge, particularly in outborn neonates who require timely medical interventions upon arrival at tertiary care centers. The Modified Sick Neonatal Score (MSNS) is a clinical scoring system used to assess the severity of illness in neonates and predict outcomes. This study aimed to evaluate the utility of the MSNS in predicting mortality in outborn neonates at a tertiary care hospital. **Materials and Methods:** A cohort study was conducted at a tertiary care hospital from April 2023 to March 2025. A total of 923 outborn neonates were included in the study. The MSNS was applied to all neonates upon admission to the neonatal intensive care unit (NICU). Demographic, clinical, and laboratory data were collected, and the association between MSNS scores and neonatal mortality was analyzed. The predictive accuracy of the MSNS was assessed using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the receiver operating characteristic curve (AUC). **Result:** Of the 923 neonates, 142 (15.4%) died during the study period. Non-survivors had significantly lower MSNS scores (8.4 ± 2.6) compared to survivors (13.2 ± 2.8, $p < 0.001$). The optimal cut-off score for predicting mortality was ≤12, with a sensitivity of 86.1%, specificity of 78.3%, and NPV of 92.4%. The MSNS showed strong discriminatory ability with an AUC of 0.894 (95% CI: 0.86–0.92). Key clinical parameters such as respiratory distress, abnormal heart rate, delayed capillary refill, and low birth weight were significantly associated with increased mortality. **Conclusion:** The MSNS is a reliable tool for predicting mortality in outborn neonates at a tertiary care center. Its high sensitivity, specificity, and NPV make it an effective screening tool for identifying neonates at high risk of mortality. Early application of MSNS can aid in timely decision-making and resource allocation in neonatal care settings.

INTRODUCTION

Neonatal mortality continues to be a major contributor to under-five mortality globally, with an estimated 2.3 million neonatal deaths reported in 2021, accounting for nearly 47% of all under-five deaths worldwide[1] In India alone, neonatal mortality remains alarmingly high, with a neonatal mortality rate (NMR) of 20 per 1,000 live births as per the Sample Registration System 2020 data.[2] A significant proportion of these deaths occur among outborn neonates, who are delivered outside tertiary care settings and subsequently referred for higher-level care due to complications such as birth asphyxia, sepsis, low birth weight, and respiratory distress. These neonates often reach referral centers late, with inadequate initial resuscitation and stabilization, placing them at significantly higher risk of adverse outcomes compared to inborn neonates.[3]

In clinical practice, early identification of critically ill neonates is essential for initiating prompt interventions and optimizing resource utilization in overcrowded neonatal intensive care units (NICUs), particularly in low- and middle-income countries (LMICs).[4] Traditional severity scoring systems like the Clinical Risk Index for Babies (CRIB) and Score for Neonatal Acute Physiology (SNAP) have been widely studied but require laboratory parameters and complex data collection, limiting their feasibility in peripheral and resource-constrained settings.[5]

The Sick Neonatal Score (SNS) and its simplified variant, the Modified Sick Neonatal Score (MSNS), have been developed as clinical tools to assess neonatal illness severity using readily observable parameters.[6] The MSNS is based on eight variables: respiratory effort, heart rate, capillary refill time, temperature, blood glucose, oxygen saturation, birth weight, and gestational age. Each variable is scored

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from 0 to 2, with a maximum possible score of 16. Lower scores indicate greater illness severity.[7] The MSNS is advantageous due to its simplicity, reproducibility, and reliance on basic clinical signs, making it practical for use even in primary and secondary care facilities.[8]

Preliminary studies have demonstrated the utility of MSNS in predicting outcomes such as mortality and length of NICU stay, with a cutoff score of ≤10 often associated with higher mortality risk.[9,10] However, most of these studies have focused on inborn neonates or heterogeneous populations, and evidence regarding the predictive accuracy of MSNS specifically in outborn neonates remains limited.[9,10] Given that outborn neonates typically present with a more compromised physiological status and delayed treatment initiation, validating the MSNS in this subgroup is crucial for informed triage and clinical decision-making.[11]

This study aimed to evaluate the utility of the Modified Sick Neonatal Score in predicting mortality among outborn neonates admitted to a tertiary care NICU. By assessing the sensitivity, specificity, and optimal cutoff of the MSNS in this high-risk population, the study intends to provide actionable evidence for its use as a screening and prognostic tool in resource-limited referral settings.

MATERIALS AND METHODS

Study Design and Setting: This was a prospective cohort study conducted in the Neonatal Intensive Care Unit (NICU) of the Department of Pediatrics at a tertiary care teaching hospital located in North India. The study was carried out over a period of 2 years, from April 2023 to March 2025. The NICU caters to both inborn and outborn neonates from rural and semi-urban regions, with a high referral load from peripheral health centers and private clinics.

Study Population and Sample Size: All outborn neonates admitted to the NICU during the study period were screened for eligibility. Inclusion criteria consisted of neonates aged 0–28 days who were born outside the study hospital and referred for medical care, provided they were admitted within 24 hours of referral and assessed within one hour of admission. Exclusion criteria included neonates with major congenital anomalies incompatible with life (e.g., anencephaly, severe cyanotic heart disease), those moribund at admission, and neonates whose caregivers did not consent or who left the hospital against medical advice before outcome ascertainment. Based on a mortality rate of 30% among outborn neonates, with a 95% confidence level and a 3% absolute margin of error, the minimum required sample size was calculated as 897.[12] To account for potential attrition, a larger sample of 1000 neonates was planned and enrolled using non-probability consecutive sampling. In the final analysis 923 neonates were enrolled after fulfilling the inclusion and exclusion criteria.

Modified Sick Neonatal Score (MSNS) Assessment: The Modified Sick Neonatal Score was assessed within the first hour of NICU admission by a trained pediatric resident under direct supervision of a neonatologist. The MSNS includes eight clinical parameters: respiratory effort, heart rate, capillary refill time, axillary temperature, random blood glucose, oxygen saturation, birth weight, and gestational age. Each parameter was assigned a score of 0, 1, or 2 based on predetermined clinical thresholds, with a total score ranging from 0 to 16.[13] Standard measurement protocols were followed: respiratory effort and heart rate were recorded via cardiorespiratory monitoring, capillary refill time was assessed at the sternum, temperature was measured using a digital axillary thermometer, oxygen saturation was measured with pulse oximetry, and blood glucose was measured using a glucometer. Birth weight and gestational age were taken from referral records when available, or estimated using the New Ballard Score if documentation was missing.[13]

Data Collection and Outcome Measurement: Demographic variables including age in days, sex, place and mode of delivery, and time from birth to admission were documented. Clinical data including presenting complaints, primary diagnosis, and interventions such as respiratory support, intravenous antibiotics, or inotropes were recorded using a standardized case record form. Each neonate was followed until discharge or in-hospital death. The primary outcome was mortality during the NICU stay. All clinical care decisions were made independent of the MSNS and followed institutional NICU management protocols.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables were tested for normality using the Kolmogorov–Smirnov test. Normally distributed variables were expressed as mean ± standard deviation (SD), and non-normally distributed variables as median with interquartile range (IQR). Categorical variables were summarized using frequencies and percentages. The MSNS scores between survivors and non-survivors were compared using an independent samples t-test or the Mann–Whitney U test, as appropriate. A Receiver Operating Characteristic (ROC) curve was plotted to evaluate the discriminatory ability of MSNS in predicting mortality, and the optimal cutoff was determined using Youden's Index. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated at this cutoff. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations: Prior to initiation, the study was approved by the Institutional Ethics Committee. Written informed consent was obtained from the parents or legal guardians of all participating neonates. Patient confidentiality and data privacy were strictly maintained throughout the study.

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RESULTS

Among 923 outborn neonates, non-survivors (n = 295) had significantly lower mean age at admission (2.5 vs. 3.3 days, $p < 0.001$), gestational age (35.2 vs. 37.1 weeks, $p < 0.001$), and birth weight (2,179.5 vs. 2,406.9 g, $p < 0.001$) compared to survivors (n = 628). Preterm birth (<34 weeks) and very low birth weight (<1500 g) were notably more common among non-survivors. Cesarean delivery (59.7% vs. 31.7%, $p < 0.001$), longer time to reach hospital, and delivery at home or peripheral centers were also significantly associated with mortality. Gender did not show a significant difference ($p = 0.135$) [Table 1].

Table 1: Baseline Characteristics of the Study Population (n = 923).

Variable	Total (n = 923)	Survivors (n = 628)	Non-Survivors (n = 295)	p-value
	Frequency (%)/mean ± SD			
Age at admission (days)	3.1 ± 2.5	3.3 ± 2.5	2.5 ± 2.3	<0.001
Gender				
Male	489 (53.0%)	322 (51.3%)	167 (56.6%)	0.135
Female	434 (47.0%)	306 (48.7%)	128 (43.4%)	
Gestational Age (Weeks)				
24–28	81 (8.8%)	11 (1.8%)	70 (23.7%)	<0.001
29–34	188 (20.4%)	70 (11.1%)	118 (40.0%)	
35–37	229 (24.8%)	140 (22.3%)	89 (30.2%)	
≥ 38	425 (46.0%)	407 (64.9%)	18 (6.1%)	
Gestational age (weeks)	36.4 ± 3.3	37.1 ± 2.8	35.2 ± 3.5	<0.001
Birth weight (g)	2,308.7 ± 703.2	2,406.9 ± 655.2	2,179.5 ± 751.7	<0.001
Birth Weight				
< 1000 g	71 (7.7%)	3 (0.5%)	68 (23.1%)	<0.001
1000–1500 g	162 (17.5%)	52 (8.3%)	110 (37.3%)	
1501–2500 g	386 (41.8%)	327 (52.1%)	59 (20.0%)	
≥ 2501 g	304 (32.9%)	246 (39.1%)	58 (19.7%)	
Mode of delivery				
Vaginal	548 (59.4%)	429 (68.3%)	119 (40.3%)	<0.001
Cesarean section	375 (40.6%)	199 (31.7%)	176 (59.7%)	
Time to reach hospital (hours)	4.2 (2.0–8.1)	3.4 (1.9–7.0)	5.1 (3.0–9.2)	<0.001
Place of delivery				
Home	115 (12.5%)	54 (8.6%)	61 (20.7%)	<0.001
Peripheral health center	227 (24.6%)	99 (15.8%)	128 (43.4%)	
Private hospital	581 (62.9%)	475 (75.6%)	106 (35.9%)	

*Median (IQR)

Non-survivors had significantly higher rates of sepsis (33.9% vs. 19.4%), respiratory distress (58.3% vs. 28.5%), need for mechanical ventilation (23.7% vs. 8.1%), surfactant use (16.9% vs. 6.2%), and inotrope requirement (20.3% vs. 8.1%), all with $p < 0.001$. Median APGAR scores at 1 and 5 minutes were significantly lower among non-survivors. Severe jaundice requiring exchange transfusion did not differ significantly between groups ($p = 0.146$) [Table 2].

Table 2: Survival Outcomes by Major Clinical Parameters.

Clinical Parameter	Total (n = 923)	Survivors (n = 628)	Non-Survivors (n = 295)	p-value
	Frequency (%)/median (IQR)			
Sepsis	222 (24.1%)	122 (19.4%)	100 (33.9%)	<0.001
Respiratory distress	351 (38.0%)	179 (28.5%)	172 (58.3%)	<0.001
Mechanical ventilation needed	121 (13.1%)	51 (8.1%)	70 (23.7%)	<0.001
Surfactant administration	89 (9.6%)	39 (6.2%)	50 (16.9%)	<0.001
Inotropes required	111 (12.0%)	51 (8.1%)	60 (20.3%)	<0.001
Severe jaundice needing exchange transfusion	36 (3.9%)	21 (3.3%)	15 (5.1%)	0.146
APGAR at 1 min	6 (4–8)	7 (5–8)	4 (2–6)	<0.001
APGAR at 5 min	8 (7–9)	9 (8–9)	6 (5–7)	<0.001

Non-survivors consistently had poorer scores across all MSNS parameters ($p < 0.001$). A higher proportion of non-survivors presented with severe respiratory distress (37.3% vs. 8.3%), abnormal heart rate (28.5% vs. 5.7%), delayed capillary refill time >4 seconds (35.9% vs. 6.4%), temperature extremes (29.8% vs. 7.6%), dysglycemia (24.4% vs. 4.5%), and low oxygen saturation <85% (34.6% vs. 7.2%). Additionally, non-survivors had a greater prevalence of extremely low birth weight <1000 g (18.3% vs. 0.6%) and very preterm birth <30 weeks gestation (22.4% vs. 2.9%). These differences underscore the predictive value of the MSNS scoring system for neonatal mortality [Table 3].

Table 3: Distribution of Individual MSNS Parameters Among Survivors and Non-Survivors.

MSNS Parameter	Scoring Criteria	Survivors (n = 628)	Non-Survivors (n = 295)	p-value
	Frequency (%)			
Respiratory effort	0 (Severe distress)	52 (8.3%)	110 (37.3%)	<0.001
	1 (Mild distress)	130 (20.7%)	90 (30.5%)	
	2 (Normal)	446 (71.0%)	95 (32.2%)	
Heart rate	0 (<80 or >180 bpm)	36 (5.7%)	84 (28.5%)	<0.001

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	1 (120–180 bpm)	100 (15.9%)	97 (32.9%)	
	2 (80–119 bpm)	492 (78.3%)	114 (38.6%)	
Capillary refill time	0 (>4 sec)	40 (6.4%)	106 (35.9%)	<0.001
	1 (3–4 sec)	108 (17.2%)	96 (32.5%)	
	2 (<3 sec)	480 (76.4%)	93 (31.5%)	
Axillary temperature	0 (<35 or >38°C)	48 (7.6%)	88 (29.8%)	<0.001
	1 (35–35.9 or 37.6–38)°C	122 (19.4%)	99 (33.6%)	
	2 (36–37.5°C)	458 (72.9%)	108 (36.6%)	
Blood glucose	0 (<40 or >150 mg/dL)	28 (4.5%)	72 (24.4%)	<0.001
	1 (40–49 or 121–150 mg/dL)	112 (17.8%)	98 (33.2%)	
	2 (50–120 mg/dL)	488 (77.7%)	125 (42.4%)	
Oxygen saturation	0 (<85%)	45 (7.2%)	102 (34.6%)	<0.001
	1 (85–91%)	118 (18.8%)	93 (31.5%)	
	2 (≥92%)	465 (74.0%)	100 (33.9%)	
Birth weight	0 (<1000 g)	4 (0.6%)	54 (18.3%)	<0.001
	1 (1000–1499 g)	47 (7.5%)	76 (25.8%)	
	2 (≥1500 g)	577 (91.9%)	165 (55.9%)	
Gestational age	0 (<30 weeks)	18 (2.9%)	66 (22.4%)	<0.001
	1 (30–36 weeks)	182 (29.0%)	182 (61.7%)	
	2 (≥37 weeks)	428 (68.1%)	47 (15.9%)	

MSNS score distribution differed significantly between survivors and non-survivors ($p < 0.001$). The majority of survivors (60.5%) had scores between 13–16, while most non-survivors (40.0%) scored between 5–8. Low scores (0–4) were more frequent among non-survivors (17.3%) than survivors (1.3%). Mean MSNS score was significantly higher in survivors (13.2 ± 2.8) compared to non-survivors (8.4 ± 2.6), highlighting the score's strong association with neonatal outcomes [Table 4].

Table 4: Distribution of Modified Sick Neonatal Scores among Survivors and Non-Survivors.

MSNS Score Range	Total (n = 923)	Survivors (n = 628)	Non-Survivors (n = 295)	p-value
	Frequency (%)/mean ± SD			
0–4	59 (6.4%)	8 (1.3%)	51 (17.3%)	<0.001
5–8	166 (18.0%)	48 (7.6%)	118 (40.0%)	<0.001
9–12	283 (30.7%)	192 (30.6%)	91 (30.8%)	0.966
13–16	415 (45.0%)	380 (60.5%)	35 (11.9%)	<0.001
Mean MSNS score	11.6 ± 3.5	13.2 ± 2.8	8.4 ± 2.6	<0.001

The MSNS cut-off score of ≤12 demonstrated good diagnostic performance for predicting neonatal mortality, with a sensitivity of 86.1% and specificity of 78.3%. The positive predictive value (PPV) was 65.4%, while the negative predictive value (NPV) was high at 92.4%, indicating strong ability to rule out mortality in neonates with scores above this threshold. The area under the ROC curve (AUC) was 0.894 (95% CI: 0.86–0.92), reflecting excellent overall accuracy. The Youden's Index (0.644) confirms that ≤12 is an optimal threshold for discriminating between survivors and non-survivors [Table 5 and Figure 1].

Table 5: Diagnostic Accuracy of MSNS Cut-off Score in Predicting Mortality.

Cut-off Score	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC (95% CI)	Youden's Index (J)
≤12	86.1	78.3	65.4	92.4	0.894 (0.86–0.92)	0.644

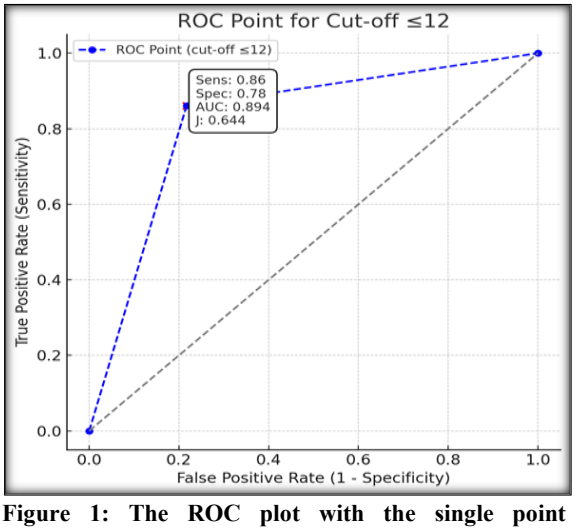

Figure 1: The ROC plot with the single point corresponding to the cut-off score ≤12.

DISCUSSION

The present study highlights the utility of the Modified Sick Neonatal Score (MSNS) in predicting neonatal mortality in a cohort of 923 outborn neonates, with a focus on key clinical parameters such as respiratory distress, heart rate abnormalities, temperature instability, and dysglycemia. In our study, non-survivors had significantly lower mean MSNS scores (8.4 ± 2.6) compared to survivors (13.2 ± 2.8). The MSNS cut-off score of ≤12 demonstrated a sensitivity of 86.1%, specificity of 78.3%, and a negative predictive value (NPV) of 92.4%. This is in line with similar studies that have explored the predictive value of neonatal scoring systems.[14,15] Gupta et al., found that MSNS cut-off score of 9.5 had a sensitivity of 100% (95% CI 39.76%-100.00%) and specificity of 90.24% (95% CI 76.87%-97.28%),

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supporting the robustness of this scoring tool across different settings.[14] Similarly, Babji et al., reported Area under the curve (AUC) as 0.811 (95%CI: 0.788-0.835), which indicates the accuracy of 81.1%, highlighting its diagnostic accuracy in a cohort of preterm neonates, which is consistent with the AUC of 0.894 (95% CI: 0.86–0.92) observed in our study.[15] Divya et al., who found that the MSNS had a sensitivity of 79.53% and specificity of 82.86% in predicting mortality in outborn neonates.[16] The high NPV (92.4%) in our study indicates that neonates with scores above the threshold are at a low risk of mortality, which can help clinicians prioritize resources and interventions for those with higher scores.

The distribution of individual MSNS parameters in our study further emphasizes its discriminative ability. Non-survivors exhibited a significantly higher proportion of severe respiratory distress (37.3% vs. 8.3%), abnormal heart rate (28.5% vs. 5.7%), delayed capillary refill time (>4 seconds, 35.9% vs. 6.4%), and extreme body temperature (29.8% vs. 7.6%), all of which have been identified as critical indicators of neonatal morbidity and mortality in previous research.[17,18] Study by Jayasheel et al., demonstrated that abnormal respiratory effort and prolonged capillary refill time were strong predictors of poor neonatal outcomes, findings corroborated by our study.[17] Furthermore, our results show that a higher proportion of non-survivors had oxygen saturation below 85% (34.6% vs. 7.2%), which aligns with the findings of Sameer et al., who identified hypoxia as a significant factor contributing to neonatal mortality, especially in outborn neonates.[18]

Our analysis also identified that non-survivors had significantly higher rates of sepsis (33.9% vs. 19.4%) and required more intensive interventions, including mechanical ventilation (23.7% vs. 8.1%) and surfactant administration (16.9% vs. 6.2%), reflecting the severity of illness at the time of admission. These findings are consistent with those of Rakholia et al., who reported similar associations between the need for mechanical ventilation and increased mortality risk in neonates.[19] The increased demand for inotropic support in non-survivors (20.3% vs. 8.1%) further emphasizes the critical condition of this group, consistent with previous studies that have linked cardiovascular instability in neonates to poor survival outcomes.[20,21] These clinical parameters are integral components of the MSNS, underscoring the tool's capacity to assess the severity of neonatal illness and predict outcomes with high accuracy.[22]

Our study also revealed that low birth weight (<1000 g) and very preterm birth (<30 weeks) were significantly more common among non-survivors (18.3% vs. 0.6% and 22.4% vs. 2.9%, respectively), reinforcing the findings of earlier studies that have shown an inverse relationship between birth weight, gestational age, and neonatal survival.[23,24] A study by Zhou et al., found that neonates with extremely low birth weight (<1000 g) had a mortality rate of around 50%, supporting the association between low birth weight and neonatal death observed in our study.[25] Furthermore, the increased mortality risk associated with preterm birth and low birth weight has been consistently reported in the literature, including study by Pusdekar et al., who found that neonates born before 32 weeks of gestation had significantly lower survival rates despite advanced neonatal care.[26]

The time to reach the hospital was another critical factor associated with mortality in our study, with non-survivors having a significantly longer median time to reach the hospital (5.1 hours vs. 3.4 hours, $p < 0.001$). This is consistent with studies by Milton et al., and Negi et al., that highlight the role of delayed transfer in increasing neonatal mortality, especially in low-resource settings where access to timely neonatal care is limited.[27,28] Our findings are aligned with the studies by Aggarwal et al., and Carvalho et al., who reported that delayed hospital arrival and delivery at peripheral health centers were associated with higher mortality rates among neonates, particularly those requiring urgent medical interventions.[29,30]

Limitations

While our study provides valuable insights into the predictive value of MSNS, several limitations must be considered. First, the study was conducted at a single tertiary care center, which may limit the generalizability of the results to other settings, particularly those with lower-resource healthcare systems. Additionally, although MSNS proved effective in predicting neonatal mortality, it does not account for all potential confounding factors such as genetic anomalies, infections, or postnatal care practices, which may also influence neonatal outcomes. Further multicenter studies are needed to validate the MSNS in diverse populations and settings.

CONCLUSION

In conclusion, our study supports the Modified Sick Neonatal Score as a valuable prognostic tool for predicting mortality in outborn neonates. Its high sensitivity, specificity, and diagnostic accuracy make it an essential tool for early identification of neonates at risk of mortality. The MSNS can help clinicians make timely decisions, prioritize resources, and intervene early in high-risk neonates, potentially improving survival rates. Future research should focus on validating MSNS in different healthcare settings and examining its potential integration with other clinical risk factors to enhance its predictive accuracy.

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