DOI: 10.7860/IJNMR/2026/87788.2479

Original Article

Paediatrics Section

Strengthening Modified Sick Neonatal Score and Delta MSNS for a Better Prediction of Outcome in Critically-ill Neonates at a Tertiary Care Centre: A Prospective Observational Study

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ABSTRACT

Introduction: The Modified Sick Neonatal Score (MSNS) and delta MSNS are simplified clinical scoring system designed to assess the severity of illness in neonates. The present study has focused to determine whether delta MSNS as an independent factor and as a combination with MSNS at admission, need for mechanical ventilation and ionotropic support will have a better prognostic value than single MSNS recording at admission.

Aim: To assess the predictive value of MSNS and Delta MSNS for outcome in critically-ill neonates.

Materials and Methods: This prospective observational study was conducted in the level III Neonatal Intensive Care Unit of Government Medical College, Kottayam, Kerala, India, from July 2023 to June 2024. A total of 122 newborns were scored using MSNS at admission and after 24 hours. Delta MSNS was calculated as the change of score over 24 hours. In addition to this the need for ionotropic support and mechanical ventilation and the number of days of hospital stay were recorded. Outcome was measured as mortality. Logistic regression was used to determine the ability to predict the outcome, of MSNS score at admission, delta MSNS, the ionotropic support and mechanical ventilation requirement.

Results: A total of 122 neonates were included in the study. The female-to-male sex ratio in the study population was 1.6:1.0. The mean score of MSNS at admission was 12.47±2.085 and 8.67±3.086, in neonates who survived and expired, respectively (p=0.001). The mean score of Delta MSNS was 1.94±1.235 and -2.20±1.935, in neonates who survived and expired, respectively (p=0.001), with a rank-biserial effect size of -0.952. So, both MSNS and delta MSNS are indicators of outcome. Receiver Operating Characteristic (ROC) curve generated using only delta MSNS, the area under the curve {unadjusted Area Under Curve (AUC)} was 0.976. The adjusted AUC (with additional variables like MSNS at admission, ionotropic requirement and mechanical ventilation requirement) was 0.999, making this model almost perfect.

Conclusion: Delta MSNS is an equally good predictor of mortality in a critically-ill neonate compared to MSNS. Also, addition of other variables makes the score almost perfect in predicting neonatal mortality.

Keywords: Disease severity scoring, Intensive care, Mortality, Newborn, Prognostic factors

INTRODUCTION

Neonatal period is a very vulnerable stage, where children are more susceptible to diseases and disease related morbidity and mortality. On a global scale, neonatal death constitutes about 46% of under-five mortality [1]. Neonatal Mortality Rate (NMR) in India is 24.9 per 1000 as per the National Family Health Survey 5 (2019-2021). NMR in rural area is higher than in urban areas, 27.5 and 18, respectively [2]. The prompt identification of sick neonates in rural areas and their referral to a higher centre for management can significantly reduce the disease burden. A neonatal illness severity scoring system can help assess the prognosis and thereby prioritise care as well as facilitate early referral in a resource-limited setting. There are multiple scoring systems available like, Clinical Risk Index for Babies (CRIB), CRIB 2, Score for Neonatal Acute Physiology (SNAP), Score for Neonatal Acute Physiology Perinatal Extension (SNAPPE), SNAP 2, SNAP-PE2, Neurobiological Risk Score (NBRS), Neonatal Mortality Prognosis Index (NMPI) [3]. Even though the aforementioned scoring systems tend to be more accurate, their need for sophisticated instruments and expensive investigations put them at a disadvantage in a resource-poor setting.

The MSNS employs parameters like respiratory effort, heart rate, axillary temperature, capillary refill time, random blood sugar, Peripheral Oxygen Saturation (SpO_2), gestational age and birth weight, that are routinely measured in the newborn care units and does not require any high-tech tools, which highlights its utility as a practical tool in a resource limited setting [4]. Multiple studies have attempted to validate the MSNS as a tool to assess illness severity and predict outcomes in neonates [5-7]. However, most of these studies have used the score as a one-time assessment [5-7]. Only one study to date has explored the dynamic use of MSNS over time- i.e., assessing changes in a neonate's condition through serial measurements [8]. This approach, called Delta MSNS, is the difference between the score at admission and the score after 24 hours of admission and offers insights into the clinical progression or improvement of the neonate [8].

In the present study, in addition to the MSNS at admission and delta MSNS parameters like need for mechanical ventilation and inotropic support are used as two additional prognostic indicators. The study analyses whether addition of these parameters help make MSNS a better prognostic predictor in a tertiary care setting.

Hence the present study aimed to study the correlation between Delta MSNS and outcome in Critically-ill neonates.

MATERIALS AND METHODS

The present prospective observational study was conducted in the level III Neonatal Intensive Care Unit of Government Medical College, Kottayam, Kerala, India, from July 2023 to June 2024, after getting approval from the Institutional Review Board (IRB Approval No: 243/2023 dt10/07/2023). Informed consent was obtained from the parents of the newborns.

Inclusion criteria: All newborns admitted to the inborn and out born unit were included in the study.

Exclusion criteria: Those babies requiring immediate surgical interventions, which prevented timely calculation of score were excluded.

Sample size calculation: In the study done by Mansoor KP et al., the frequencies of score 2 for gestational age of neonates among expired and discharged cases were 7.2% and 92.7%, respectively [4].

Using the formula $N= 4pq/d^2$

Where, N is the sample size, 'p' is the expected proportion of neonates in the discharged group with a score of 2 for gestational age, q is (100-p) and d is absolute precision fixed at 5%.

N= (4×0.927×0.072)/0.052= 106.7

The sample size required for the study was 107 neonates.

Study Procedure

MSNS comprises of eight clinical parameters [Table/Fig-1] [5]. Each parameter is given a score from 0 to 2, and the sum will be calculated with a maximum score of 16 and minimum score of 0. Respiratory effort and rate were assessed clinically. Neonates on ventilator support were given a score of zero, as the rate was set according to illness. Heart rate was measured using the Comen Star8000f multiparameter monitor. Temperature was measured by placing a digital thermometer in the axilla for one minute. Capillary refill time was assessed by applying gentle pressure to the sternum with the examiner's finger and counting the time until colour returned. Random blood sugar was measured using the On Call Plus glucometer on heel-prick blood. SpO_2 was measured by Comen Star8000f multiparameter monitor in the right upper limb in room air. Gestational age was determined based on the mother's last menstrual period or, if that was unreliable, from her first obstetric ultrasound report. Birth weight was recorded from the neonate's available medical documents.

Parameters	Score 0	Score 1	Score 2
Respiratory effort	Apnoea or grunt	Tachypnoea (RR >60/min) with or without retractions	Normal (RR 40-60/min)
Heart rate	Bradycardia or asystole	Tachycardia (HR>160/min)	Normal (HR 100-160/min)
Axillary temperature (°C)	<36	36-36.5	36.5-37.5
Capillary refill time (sec)	>5	3-5	<3
Random blood sugar (mg/dL)	<40	40-60	>60
SpO_2 (room air,%)	<85	85-92	>92
Gestational age (in weeks)	<32	32 to 36 weeks+ 6/7 days	37 weeks and above
Birth weight (in kilogram)	<1.500	1.500 to 2.490	2.500 or above

[Table/Fig-1]: Modified Sick Neonatal Score (MSNS) [5].
HR: Heart rate, RR: Respiratory rate

All the newborns were scored using MSNS at the time of admission and after 24 hours of admission. Change in MSNS was calculated as delta MSNS.

Delta MSNS= MSNS at admission - MSNS after 24 hours [8].

In addition to this the need for ionotropic support and mechanical ventilation were recorded. Outcome was measured as mortality. The number of days of hospital stay was also recorded.

STATISTICAL ANALYSIS

Data collected were entered in Microsoft Excel 2021 and analysed using Python (scikit-learn, scipy, seaborn/matplotlib), with Artificial Intelligence (AI) Data Analyst, Julius. Mann-Whitney test was used to compare the scores between the neonates who were expired and survived. The rank-biserial effect size was determined to measure the strength of the association between the two groups. Receiver operating characteristic curve was used to create a model for predicting the outcome, using MSNS score at admission, delta MSNS, the ionotropic support and mechanical ventilation requirement. An odds ratio was calculated to measure the association between delta MSNS and the outcome. Spearman's correlation was used to determine the correlation between delta MSNS and number of days of hospital stay. A p-value below 0.05 was considered as significant.

RESULTS

A total of 122 neonates were enrolled in the study, out of which 15 (12.3%) expired. The female-to-male sex ratio in the study population was 1.6:1.0. 57 (46.7%) of the neonates were preterm. A total of 74 (60.7%) of the neonates had low birth weight (<2500 grams). The need for mechanical ventilation and inotropic support was seen in 31 (25.4%) and 23 (18.8%) of the study population, respectively [Table/Fig-2].

Baseline characteristics		n (%)
Gender	Male	47 (38.5)
	Female	75 (61.5)
Type of delivery	Normal	65 (53.3)
	Caesarean	43 (35.2)
	Assisted	14 (11.5)
Gestational age	Preterm	57 (46.7)
	Term	65 (53.3)
Birth weight	<2500 g	74 (60.6)
	>2500 gm	48 (39.4)
Ventilator support	Required	31 (25.4)
	Not required	91 (74.6)
Inotropic support	Required	23 (18.8)
	Not required	99 (81.2)
Outcome	Survived	107 (87.7)
	Expired	15 (12.3)

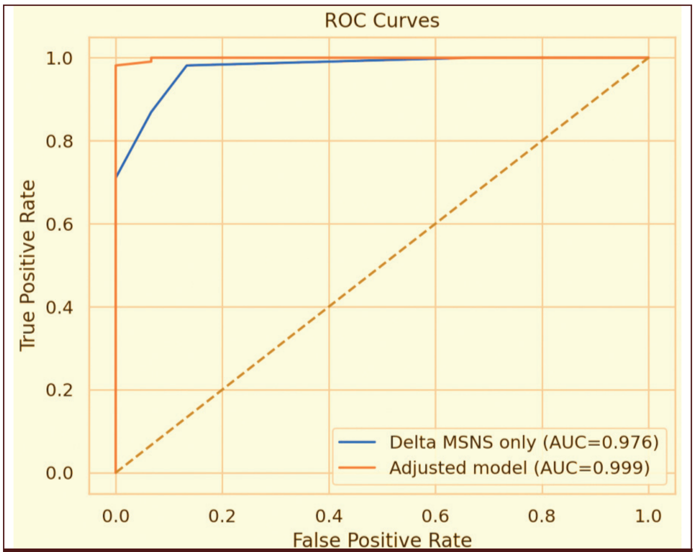
[Table/Fig-2]: Baseline characteristics of the study population (N=122).

The mean score of MSNS at admission was significantly higher in neonates who have survived (12.47±2.085) compared to those in the expired group (8.67±3.086) (p=0.001), suggesting that MSNS at admission is a reliable indicator for distinguishing survival outcomes in neonates. The mean change in MSNS score (Delta MSNS) was positive in the survived group (1.94±1.235) and negative in the expired group (-2.20±1.935), with the difference being statistically significant (p=0.001). This suggests that, the clinical improvement, seen as an increase in MSNS score over time is associated with a favourable outcome, whereas deterioration correlates with mortality. Additionally, the rank-biserial correlation coefficient (r=-0.952) (p=0.001), shows a very strong inverse correlation between delta MSNS and mortality, indicating that higher delta MSNS values are strongly predictive of survival, while declining score is associated with mortality [Table/Fig-3].

Parameters	Survived group (Mean±SD)	Expired group (Mean±SD)	p-value
MSNS at admission	12.47±2.085	8.67±3.086	0.001
Delta MSNS	1.94±1.235	-2.20±1.935	0.001
Effect size (Rank-biserial correlation)	-	-0.952	0.001

[Table/Fig-3]: Comparison of MSNS and delta MSNS between survived and expired neonates.

The ROC curves were generated using delta MSNS as a single variable and also with additional variables like MSNS at admission, ionotropic requirement and mechanical ventilation requirement. In the model using only delta MSNS, the area under the curve (unadjusted AUC) was 0.976, suggesting that there is a 97.6% chance that a randomly chosen neonate who survived will have a higher delta MSNS score than a randomly chosen neonate who expired. The adjusted AUC was 0.999. This indicates that, with the inclusion of additional variables (MSNS at admission, ventilator requirement, and inotropic requirement), the model's ability to discriminate improves even further, reaching an AUC of 0.999. This suggests that the model is almost perfect in distinguishing between the two outcomes [Table/Fig-4].



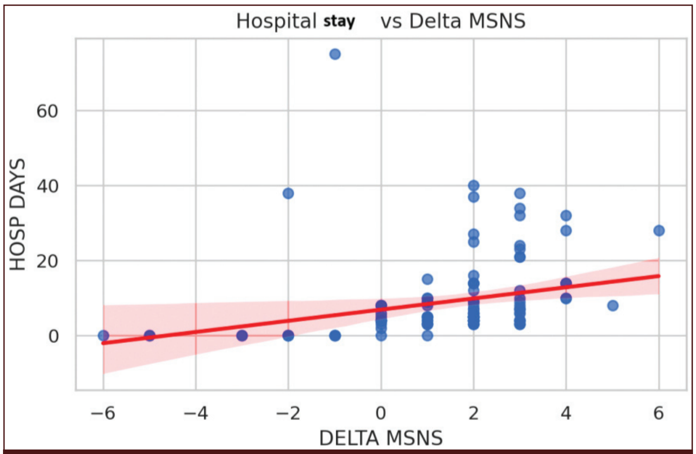
[Table/Fig-4]: ROC curves showing AUC of unadjusted and adjusted models.

The odds ratio for delta MSNS was 5.182. This means that for each one-unit increase in Delta MSNS, the odds of survival are approximately 5.18 times higher.

The mean number of days of hospital stay was 10.27±11.03 days. The Spearman correlation coefficient showed a value of 0.5025, (p-value < 0.001) indicates a moderate positive correlation between delta MSNS and hospital stay. This means that as delta MSNS increases, the length of hospital stay tends to increase as well, suggesting that better improvement in the MSNS is associated with longer hospital stays [Table/Fig-5].

DISCUSSION

In the present study, 122 neonates admitted to the level III neonatal intensive care unit of the study Institute were included. The female-



[Table/Fig-5]: Correlation between delta MSNS and length of hospital stay.

to-male sex ratio in the study population was 1.6:1.0. 57 (46.7%) of the neonates were preterm. The present study had an almost equal distribution of preterm and term babies, whereas, other studies reported an uneven distribution based on gestational age [8,9]. A total of 74 (60.7%) of the neonates had low birth weight (<2500 grams), similar to most of the studies [6,8,9]. The need for mechanical ventilation and inotropic support was seen in 31 (25.4%) and 23 (18.8%) of the study population, respectively. The mortality rate of the present study is 15 (12.3%), similar to studies conducted in Nepal and India [5,9].

The MSNS is an easy to score disease severity scoring system that can be utilised in a resource poor setting. In the present study, conducted in a tertiary care setting, the mean score of MSNS at admission was 12.47±2.085 and 8.67±3.086, in neonates who survived and expired, respectively. This shows that a MSNS score can predict mortality, which is similar to other studies conducted [4-10].

The mean score of Delta MSNS was 1.94±1.235 and -2.20±1.935, in neonates who survived and expired, respectively, with a rank-biserial effect size of -0.952. So, an improvement in MSNS score at 24 hours of admission decreases the chance of mortality, whereas the decline in score is associated with an increased risk of death.

A ROC plot of delta MSNS, shows an AUC of 0.976. This is in par with the AUC of MSNS at admission in other studies, where the values range from 0.811 - 0.98 [4-10]. This shows the utility of delta MSNS alone as a predictor of mortality. An adjusted ROC with the inclusion of additional variables (MSNS at admission, ventilator requirement, and inotropic requirement), showed an AUC of 0.999, making this model almost perfect in predicting outcome in a critically-ill neonate.

In the present study, a moderately positive correlation was seen between delta MSNS and length of hospital stay, which means an improvement of MSNS score is associated with longer hospital stay. This is different from previous study, which shows a negative correlation, suggestive of shorter hospital stay [8]. The reason may be the difference in discharge policy and back referral causing longer stay of sick children and early death may have caused shorter duration of stay.

Limitation(s)

The calculated sample size may have created an overfitting model, due to smaller size. This can be overcome by a further study with larger sample size.

CONCLUSION(S)

The delta MSNS is an equally good predictor of mortality in a critically-ill neonate compared to MSNS. Also, addition of variables like MSNS at admission, ionotropic requirement and ventilation requirement to delta MSNS, make the score almost perfect in predicting neonatal mortality, thereby making it more useful in a tertiary care setting. From a clinical perspective, this combined scoring approach can facilitate early risk stratification, enabling clinicians to promptly identify high-risk neonates who may benefit from intensified monitoring and aggressive therapeutic interventions. It may also support dynamic clinical decision-making, as changes in MSNS over time reflect ongoing physiological status and response to treatment. Furthermore, the use of such a composite score can aid in resource allocation in tertiary care neonatal intensive care units, optimise prioritisation of critical care support, and provide an objective framework for prognostic counselling of caregivers. For overcoming the overfitting model, a study with larger sample size can be conducted.

Acknowledgement

The authors would like to acknowledge the cooperation of the staff and the caregivers.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jan 29, 2026
- Manual Googling: Apr 15, 2026
- iThenticate Software: Apr 21, 2026 (8%)

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: **Jan 28, 2026**
Date of Peer Review: **Mar 16, 2026**
Date of Acceptance: **Apr 22, 2026**
Date of Publishing: **Jun 30, 2026**