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Original Article

Paediatrics Section

Assessment of Neonates with Extended Sick Neonate Score (ESNS) for Predicting Mortality in a Tertiary Care Center in Dharwad, Karnataka, India: A Prospective Cohort Study

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ABSTRACT

Introduction: High neonatal mortality rates may be attributed to the lack of early recognition of severe illness, early and safe referral, and proper care. Therefore, there is a need to develop a simple, cost-effective scoring system that can be quickly applied to newborns referred from peripheral to tertiary care settings in resource-constrained areas. The Extended Sick Neonate Score (ESNS) is one such scoring system used to assess the severity of illness in critically ill neonates and predict their outcomes.

Aim: To evaluate the effectiveness of the Extended Sick Newborn Score in predicting outcomes for neonates admitted to the Neonatal Intensive Care Unit (NICU) of a tertiary care centre.

Materials and Methods: This prospective cohort study included 122 outborn neonates admitted to the NICU of SDM College of Medical Sciences and Hospital in Dharwad, Karnataka, India, from June 2021 to June 2022. All the required parameters for scoring, such as respiratory effort, heart rate, mean blood pressure, axillary temperature, capillary filling time, random blood sugar, SpO_2, Moro reflex, and modified Downe's score, were assessed and documented in a predesigned proforma. The ESNS was calculated upon admission to predict the outcomes. Statistical analysis included ANOVA test and independent t-test, using SPSS version 17.0 and MS Excel.

Results: The study evaluated a total of 122 neonates, including 78 males and 44 females. Of these, 99 were term neonates and 23 were preterm neonates. The mean age for term neonates was 8.5 days ±8.6, and for preterm neonates, it was 4.1 days ±4.3. Term neonates with an ESNS Score ≤11 exhibited higher mortality, while preterm neonates with an ESNS score ≤12 showed higher mortality. The sensitivity and specificity of the ESNS score in predicting death were 78.57% and 99.07%, respectively. The ESNS score at admission was significantly lower in non-survivors compared to survivors, and it demonstrated a positive correlation with the outcome.

Conclusion: This study found a significant correlation between the ESNS score at admission and in-hospital mortality. The use of the ESNS score is an acceptable method for risk stratification and prognosis of newborns in the NICU.

Keywords: Late onset sepsis, Out born neonate, Outcome, Prematurity

INTRODUCTION

Neonatal period, which occurs just after birth, is characterised by many physiological changes in the baby and psychological changes in parents and family, which can be adjusted by educating them about family planning and infant care [1]. Newborn care consists of evaluating the need for resuscitation, conducting a complete physical examination, administering prophylactic medications and vaccines, ensuring adequate feedings, promoting safe sleep, maintaining newborn hygiene, and addressing other important areas for baby well-being [2].

Globally, India accounts for 25% of neonatal deaths, contributing to one million neonatal deaths worldwide [3]. A recent survey of Indian NICUs found extreme variation in survival rates, particularly in the extremely preterm group, with a median survival of 44% (IQR 18-60) in those <28 weeks of Gestational Age (GA) [4]. Neonatal mortality remains a significant public health challenge in India, where the neonatal mortality rate is estimated at 21 per 1000 live births, with outborn neonates at a higher risk compared to inborn neonates [5,6].

In recent years, the number of centers providing NICU care for neonates in India has grown exponentially [7]. Neonatal deaths are unequally distributed worldwide, with 99% occurring in low- and middle-income countries [8]. However, preventing mortality due to the three main causes of death (complications associated with premature birth, causes related to childbirth, and sepsis) is possible with the implementation of simple and low-cost interventions, even in countries with limited resources [9]. Therefore, a reliable but simple scoring system to assess the well-being of newborns is necessary to predict mortality and morbidity.

Scoring systems use weighted demographic, physiological, and clinical data to calculate a score that quantifies infant morbidity. The principle for such an approach has long been established in many branches of medicine [10]. Various scoring systems have been developed to predict mortality and morbidity in the intensive care unit, such as SNS, Score for Neonatal Acute Physiology-Perinatal Extension (SNAPPE 1 and 11), Clinical Risk Index for Babies (CRIB I and 11), Temperature Oxygenation Perfusion Blood Sugar (TOPS), and ESNS. The proposed ESNS can be rapidly and reliably applied to newborns referred from the periphery to tertiary care [11-13].

A study conducted by Mathur NB et al., evaluating the effectiveness of ESNS in predicting mortality in outborn neonates showed that

ESNS had a higher area under the Receiver Operating Character (ROC) curve (0.84) compared to other scoring systems like CRIB 11 and SNAP 11, indicating better predictive efficacy [11]. Additionally, a study conducted by Shah BH et al., showed higher sensitivity (0.94) and specificity (0.83) in mortality prediction compared to other scores like SNS and TOPS [12]. The Extended Sick Neonatal Score (ESNS) can predict "in-hospital mortality" outcome with satisfactory sensitivity and specificity [13]. ESNS can assist in the early identification of high-risk newborns and help in timely intervention, which is crucial in reducing neonatal mortality. The ESNS scoring system is easier to apply, and the score can be determined immediately compared to other scoring systems like SNAPPE-11, as it does not include parameters like blood pH, paO_2/FiO_2 ratio, multiple seizures, and urine output, which require 12 to 24 hours of observation time [11].

Hence, the present study aimed to apply ESNS in neonates received in the NICU and assess its impact on the neonate's outcome.

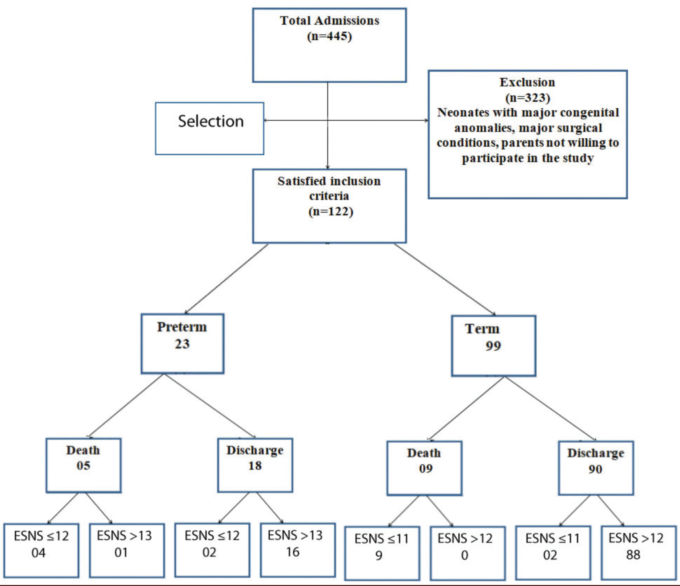
MATERIALS AND METHODS

A prospective cohort study was conducted at the NICU of SDM Medical College and Hospital, Dharwad, Karnataka, India, over a one-year period from June 2021 to June 2022. This study was approved by the institutional ethical committee (Protocol number: IEC: 37:2021), and informed consent was obtained from the parents for their participation in the study.

Inclusion criteria: All term and preterm outborn babies within 30 minutes of admission to the NICU were included.

Exclusion criteria: Neonates with major congenital anomalies, major surgical conditions, and parents who were not willing to participate in the study were excluded.

Sample size: Out of 445 neonates, a total of 122 neonates satisfying the inclusion and exclusion criteria, who presented in the department within the study duration, were enrolled in the study through purposive sampling [Table/Fig-1].



[Table/Fig-1]: Consort Flowchart- Overview of study participants.

Procedure

Within 30 minutes of the neonates' arrival at the NICU, a detailed history was taken, and an examination was performed. Antenatal history, including the risk factors, was noted. The collected data included the following: gender, GA, age of the neonate, indication for referral, diagnosis at admission, delivery method, anthropometry, heart rate, axillary temperature, respiratory effort, mean blood pressure, capillary filling time, random blood sugar, and oxygen saturation. Neurological assessment was done using the Moro Reflex, and respiratory distress assessment was done using the Modified Downe's Score. Data were collected using a pre-designed proforma. All neonates were assigned a score using the ESNS system. The ESNS system has nine parameters, with each parameter assigned a score of 0, 1, or 2 based on the neonate's condition. Using the ESNS system, a score of less than 11 in term neonates and less than 12 in preterm neonates was found to predict mortality [Table/Fig-2] [13].

Parameter	Score		
	0	1	2
Respiratory effort	Apnea	Rate >60/min± Retraction	Rate 40-60/min
Heart rate (beats per minute)	Bradycardia/ Asystole	>160	100-160
Mean blood pressure	<5th percentile	5-50th	>50th
Axillary temperature (°C)	<36	36.0-36.5	36.5-37.5
Capillary filling time (s)	>5	3-5	<3
Random blood sugar (mg/dL)	<45	45-60	>60
SpO_2 (% in room air)	<85	85-92	>92
Moro reflex	Absent	Depressed/ Exaggerated	Corresponding to Gestational Age (GA)
Modified Downes' score*	>6	2-6	0-2

[Table/Fig-2]: Extended Sick Neonatal Score (ESNS) system [13].
*Modified Downe's score represent a composite score including five parameters (each carrying 0, 1, 2 points, with minimum score 0 to maximum score 10) i.e., respiratory rate, retraction, grunt, cyanosis, air entry [13]

STATISTICAL ANALYSIS

The data were analysed using statistical software, including SPSS version 17.0 and MS Excel. The types of delivery were compared with the mean days of NICU using an ANOVA test. The comparison of the mean ESNS between males and females was conducted using an independent t-test.

RESULTS

Out of the 122 neonates, 68 (87.18%) were male term neonates and 10 (12.82%) were male preterm neonates. Female term neonates accounted for 31 (70.45%) and female preterm neonates accounted for 13 (29.55%). The mean age at admission for term neonates was 8.5 days ±8.6, while for preterm neonates it was 4.1 days±4.3 [Table/Fig-3].

Sex	Term n (%)	Preterm n (%)	Total n (%)
Male	68 (87.18)	10 (12.82)	78 (63.93)
Female	31 (70.45)	13 (29.55)	44 (36.07)
Total	99 (81.15)	23 (18.85)	122 (100)
Mean Gestational Age (GA) (weeks) (mean±Std. Dev)	38.55 (±0.989)	33.44 (±1.96)	
Mean age at admission (days)	8.5±8.6	4.1±4.3	

[Table/Fig-3]: Distribution of neonates according to gender and Gestational Age (GA).

In the present study, the majority of the neonates (48.36%) were delivered by LSCS, followed by full-term vaginal delivery (40.16%)

and preterm vaginal delivery (11.48%). Out of the 122 neonates, 77 (63.11%) were admitted within the first week of life (1-7 days), 20 (16.39%) in the second week (8-14 days), and 25 (20.49%) after two weeks (14 days). Regarding the duration of NICU stay, 69 (56.56%) neonates stayed for 1-7 days, 36 (29.51%) stayed for 8-14 days, and 17 (13.93%) stayed for more than 14 days [Table/Fig-4].

Neonatal parameters	Number (N=122)	Percentage (%)
Day of life		
1-7 days	77	63.11
8-14 days	20	16.39
>14 days	25	20.49
Mode of delivery		
LSCS	59	48.36
FTVD	49	40.16
PTVD	14	11.48
Duration of hospital stay		
1-7 days	69	56.56
8-14 days	36	29.51
>14 days	17	13.93
Total	122	100.00

[Table/Fig-4]: Distribution of neonates according to Age (day of life) at admission and mode of delivery.
LSCS: Lower segment caesarian section; FTVD: Full term vaginal delivery, PTVD: Preterm vaginal delivery

Among the 122 neonates admitted to the NICU, 31 (25.41%) were diagnosed with pneumonia, 17 (13.93%) with perinatal asphyxia, 15 (12.30%) with Meconium Aspiration Syndrome (MAS), 13 (10.65%) with neonatal convulsions, 12 (9.836%) with neonatal hyperbilirubinemia, 11 (9.02%) with Late-Onset Sepsis (LOS), 9 (7.38%) with Early-Onset Sepsis (EOS), 6 (4.92%) with Transient Tachypnea of the Newborn (TTNB), 5 (4.09%) with Preterm and Low Birth Weight (PT and LBW) care, and 3 (2.46%) with Hyaline Membrane Disease (HMD) [Table/Fig-5].

Diagnosis	Number (N=122)	Percentage
Perinatal asphyxia	17	13.93
Meconium aspiration syndrome	15	12.29
Early onset sepsis	9	7.37
Late onset sepsis	11	9.01
Pneumonia	31	25.40
Preterm and LBW care	5	4.09
Hyaline membrane disease	3	2.45
Transient tachypnea of newborn	6	4.91
Neonatal convulsions	13	10.65
Neonatal hyperbilirubinemia	12	9.83

[Table/Fig-5]: Distribution by diagnosis at admission.
MAS: Meconium aspiration syndrome; NNJ: Neonatal jaundice; LOS: Late onset sepsis; EOS: Early onset sepsis; TTNB: Transient tachypnea of newborn; PT: Preterm; LBW: Low birth weight; HMD: Hyaline membrane disease

The mean NICU stay for neonates born through preterm vaginal delivery was 12.6 days, for full-term vaginal delivery was 6.8 days, and for neonates delivered by LSCS was 7.9 days. Neonates born by preterm vaginal delivery had a longer duration of stay in the NICU [Table/Fig-6].

The mean ESNS score was 14.8 for neonates delivered by preterm vaginal delivery, 15.6 for full-term vaginal delivery, and 15.3 for neonates delivered by LSCS. There was no significant association found between ESNS scores and duration of hospital stay, gender, or type of delivery [Table/Fig-7].

Comparative data	Mean	SD	Median	IQR
PTVD	12.6 days	7.8	11.0	4.0
FTVD	6.8 days	4.4	7.0	3.0
LSCS	7.9 days	6.1	7.0	3.5
F-value	5.8004			
p-value	**0.0039***			
Pair wise comparisons by Tukeys post-hoc procedures				
PTVD vs FTVD	**P=0.0027***			
PTVD vs LSCS	**P=0.0176***			
FTVD vs LSCS	P=0.5362			

[Table/Fig-6]: Comparison of types of delivery with mean days of NICU stays by one-way ANOVA.
*p<0.05

Comparative ESNS scores	Mean (±Std. Dev)	Median	p-value
Types of delivery			
PTVD	14.8 (2.5)	14.0	0.687
FTVD	15.6 (3.1)	17.0	
LSCS	15.3 (3.3)	17.0	
Gender			
Male	15.29 (3.2)	16.0	0.209
Female	15.7 (3)	17.0	
Day of admission			
1-7 days	14.64 (3.38)	16	**0.001***
8-14 days	13.15 (4.91)	15	
>14 days	16.86 (1.65)	17	
Duration of hospital stay			
1-7 days	15.55 (3.6)	17	0.542
8-14 days	14.92 (2.31)	15	
>14 days	15.73 (2.31)	16	

[Table/Fig-7]: Comparison of types of delivery, gender, duration of admission, duration of hospital stay with mean ESNS by one-way ANOVA.
p<0.05 is statistically significant

Based on the ESNS score, term neonates with an ESNS score ≤11 had a higher mortality rate compared to term neonates with an ESNS score ≥12. Among the 11 term neonates with an ESNS score ≤11, nine expired and two survived. Among the 88 term neonates with an ESNS score ≥12, all survived. Similarly, among the six preterm neonates with an ESNS score ≤12, four expired and two survived. Among the 17 preterm neonates with an ESNS score ≥13, one expired and 16 survived [Table/Fig-8].

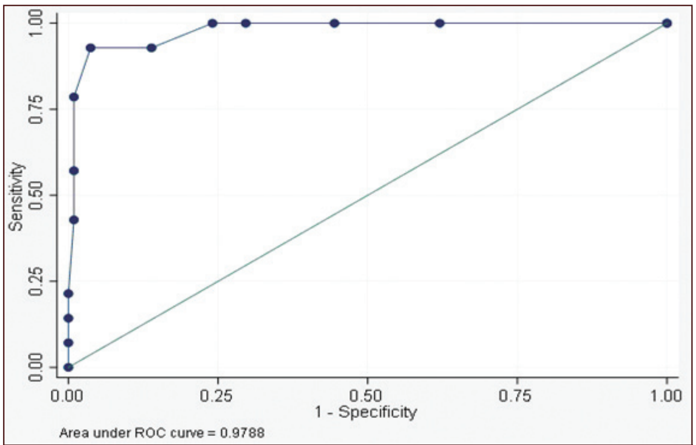
Term/preterm	ESNS scores	Death n (%)	Survived n (%)	Total	p-value
Term	≤11	9 (81.82)	2 (18.18)	11	-
	>12	0 (0.00)	88 (100.00)	88	
	Total	9	90 (90.91)	99	
Preterm	≤12	4 (66.67)	2 (33.33)	6	0.01*
	>13	1 (5.88)	16 (94.12)	17	
	Total	5 (21.74)	18 (78.26)	23	
Grand total		14 (11.48)	108 (88.52)	122	

[Table/Fig-8]: Comparison of ESNS scores in term/preterm with mortality by chi-square test.
p-value <0.05 is statistically significant; p-value could not be calculated for term babies as one of the cells contains zero

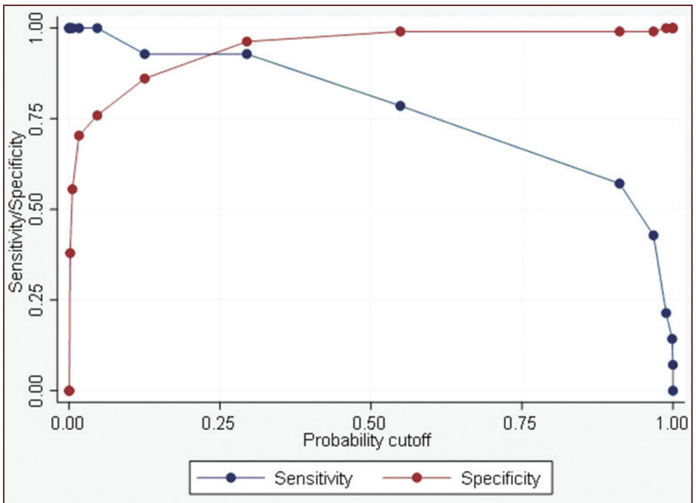
Based on the statistical analysis, the ESNS system had a sensitivity of 78.57% and specificity of 99.07% in predicting death. The positive predictive value was 91.67% and the negative predictive value was 97.27% [Table/Fig-9]. The area under the curve was 0.9778, indicating that the ESNS score had a high significance in predicting mortality [Table/Fig-10]. The study identified the point of maximum sensitivity and specificity, as there were 14 neonates with an ESNS score <11 in term neonates and <12 in preterm neonates who experienced mortality [Table/Fig-11].

Summery	Value
Sensitivity	78.57%
Specificity	99.07%
Positive predictive value	91.67%
Negative predictive value	97.27%

[Table/Fig-9]: Sensitivity and specificity of ESNS in predicting death.



[Table/Fig-10]: ROC curve of mortality (death) by ESNS.



[Table/Fig-11]: Sensitivity vs specificity.

DISCUSSION

Within 30 minutes of arrival at the emergency room, the baby was assessed by measuring oxygen saturation, heart rate, blood pressure, axillary temperature, random blood sugar, and weight. In the present study, out of the 122 neonates, 78 (63.93%) were male and 44 (36.07%) were female neonates. This finding is similar to the study conducted by Ray S et al., where out of 961 neonates, 577 (60.04%) were males and 502 (52.24%) were females. Another study by Mansoor KP et al., in 2019 included 585 neonates, out of which 320 (54.7%) were male and 265 (45.3%) were female [13,14]. In the present study, term babies constituted approximately 99 (81.15%) and preterm babies constituted approximately 23 (18.85%). In the study by Mansoor KP et al., 345 (59%) were term and post-term, while preterm infants were 240 (41%). Another study by Rathod D et al., included 303 neonates, of which 238 (81.8%) were term and 65 (21.5%) were preterm [15].

In the present study, the newborns were admitted with various conditions, including pneumonia (25.41%), perinatal asphyxia (13.93%), meconium aspiration syndrome (12.30%), late-onset sepsis (9.02%), early-onset sepsis (7.38%), and neonatal convulsions (2.46%). In the study by Ray S et al., the common indications for referral were sepsis (31.6%), birth asphyxia (23.4%), and jaundice (21.4%) [13]. In the study by Mansoor KP et al., the predominant causes of admissions were sepsis (239, 40.9%), jaundice (143, 24.4%), birth asphyxia (78, 13.3%), and respiratory distress syndrome (62, 10.6%) [14]. In the study by Rathod D et al., the common indications for referrals were sepsis (30.7%), birth asphyxia (17.5%), and respiratory distress (15.2%) [15].

In the present study, the mortality rate was 11.4%, with 14 out of 122 cases resulting in death. Among these cases, nine were term babies and five were preterm babies. In the study by Ray S et al., the mortality rate was 19.2% [13]. In the study by Mansoor KP et al., the mortality rate was 16.2% [14]. In the study by Rathod D et al., the mortality rate was 19.8% [15]. In the study by Muktan D et al., the mortality rate was 17.6% [16]. In the study by Karthik AT et al., the mortality rate was 16.2% [17].

In the present study, based on the ESNS score, term neonates with an ESNS score ≤11 had a higher mortality rate compared to term neonates with an ESNS score ≥12. Similarly, preterm neonates with an ESNS score ≤12 had a higher mortality rate compared to preterm neonates with an ESNS score >13. In the study by Ray S et al., an ESNS score ≤11 for term neonates and ≤12 for preterm neonates best predicted mortality [13]. In another study by Rathod D et al., using SNS, the average score for all neonates was 10, while it was 6 for those who expired, and a cut-off value of ≤8 predicted mortality [15]. Another study by Mansoor KP et al., found that using MSNS, the optimum cutoff value obtained for predicting mortality was 10 [16]. In a study by Marete IK et al., a CRIB-II score of more than four was found to have better prediction for mortality among low birth weight babies [18]. In another study by Muktan D et al., a SNAPPE-II score of 38 may be associated with high mortality [16].

Based on the statistical analysis in our study, the ESNS system showed a sensitivity of 78.57% and specificity of 99.07% in predicting mortality. In the study by Ray S et al., an ESNS score ≤11 for term neonates had a sensitivity of 85.9% and specificity of 89.8%, while an ESNS score ≤12 for preterm neonates had a sensitivity of 92.3% and specificity of 76.7% [13]. In the study by Rathod D et al., using SNS, the mortality rate was 19.8% with a sensitivity of 58.3% and specificity of 52.7% [15]. The study by Mansoor KP et al., using MSNS, showed a sensitivity of 80% and specificity of 88.8% [14]. Another study by Marete IK et al., using CRIB-II, had a sensitivity of 80.6% and specificity of 75.3% [18]. In the study by Muktan D et al., SNAPPE-II showed a sensitivity of 84.4% and specificity of 91% [16].

In a study by Jamoh Y and Begum R, longer transport time was associated with higher mortality in neonates, which is similar to the present study [19]. Additionally, in the same study, neonates transported using private transport had higher mortality than those transported using government transport, which is also consistent with findings of present study. It is important to note that factors such as the treatment received by the newborn before seeking treatment in the NICU, the time required to transfer the newborn from the referring doctor, and the mode of transport used to shift the patient (private vehicle/ambulance) can have a direct impact on the ESNS and the outcome of the patient [19]. Therefore, these factors were considered as confounding factors in the present study.

Limitation(s)

In this study, the sample size was small as it only included outborn neonates who were referred to the hospital. Therefore, the applicability of the ESNS score in predicting mortality in inborn neonates is limited.

CONCLUSION(S)

It was found that the ESNS scoring system is a fast and effective method for predicting neonatal mortality, with satisfactory sensitivity and specificity in both term and preterm neonates referred to a tertiary healthcare center. The ESNS score is also considered an acceptable tool for risk stratification and prognosis of newborns. Whether using absolute values or changes over time, the ESNS score shows potential as a useful tool for clinicians during bedside assessment or for clinical research trials. However, it is important to note that this study was conducted in a single hospital in a specific region of India, so the results may not be generalisable to other settings. Therefore, a multicentric study covering a larger portion of India is needed to assess the efficacy of the ESNS system in predicting mortality in both inborn and outborn neonates.

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