International Journal of Contemporary Pediatrics
Naithani K et al. Int J Contemp Pediatr. 2023 Oct;10(10):1507-1513
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20232861

Original Research Article

Comparing neonatal intensive care unit outcomes of intramural and extramural neonates using the modified sick neonate score

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Received: 02 September 2023
Accepted: 15 September 2023

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ABSTRACT

Background: India contributes to one-fifth of the world's annual childbirths and one-fourth of the neonatal mortality burden, with rural areas having higher mortality rates. Several scoring systems have been used to independently predict neonatal outcomes in babies born elsewhere and transported to a facility (extramural) and in the inborn or intramural neonates. We used the modified sick neonate score (MSNS) to compare the outcomes in extramural and intramural neonates. The score considers eight parameters and quantitatively measures the neonates' status. This study aimed to determine whether the MSNS effectively predicts mortality among the two study groups.
Methods: 410 neonates were considered for this prospective analytical study conducted at GMERS Hospital, Vadodara, a tertiary care center- over a duration of 20 months. Neonates were followed during their NICU stay, and outcomes were correlated with their scores recorded on admission.
Results: The intramural newborns had higher MSNS than the extramural neonates (13 and 12, respectively), with the difference statistically significant. At an optimal cut-off of <11, MSNS has a sensitivity of 85.11% and a specificity of 75.76% in predicting neonatal outcomes. The AUC was 0.859 (95% CI:0.822 to 0.891) with a positive predictive value of 31.2%, a negative predictive value of 97.5%, and an accuracy of 76.83%.
Conclusions: The MSNS effectively predicts mortality among intramural and extramural neonates, with the range being higher for inborn babies- indicating a better prognosis.

Keywords: MSNS, Sick neonate score, Neonatal mortality scoring, Outcomes, Intramural, Extramural

INTRODUCTION

India contributes to a fifth of the world's annual childbirths, with almost 25 million children born yearly.[1] The latest National Family Health Survey (NHFS-5) for 2019-2021 indicates that 88% of these births occurred in hospitals, an increase since the last survey in 2015-16, which is remarkable because the majority of deliveries in India occur in rural areas.[2] Despite rising institutional delivery rates, the neonatal mortality rate for rural areas remains high at 27.5 per 1000 live births. We currently account for one-fourth of the global mortality burden, and to meet the child health goals under SDG, we must reduce our NMR from 21.66 to less than 12 per 1000 live births by 2030.[3] This goal can be achieved by reducing early neonatal mortality, the most fragile period of a newborn's life. To improve the survival of neonates in rural areas, 894 special neonatal care units (SNCUs) have been set up at district and sub-district levels since 2011. These units are equipped to care for all "sick newborns" (except surgical care) and serve as the first referral units for primary healthcare centers.[4] Incentives like JSSK have increased the accessibility and affordability of maternal and child care and expedited transport to higher facilities.[5] One would expect the presence of a referral system to remedy the urban-rural divide in healthcare. However, several other factors affect the outcomes in these cases, like the absence of proper communication (verbal or written) with the receiving facility, lack of trained professionals, and poorly equipped modes of transport. Neonates with unique physiological needs can suffer from biochemical derangements due to such lapses in care.[6] We are also experiencing inequitable distribution of resources due to a lack of regionalization; having efficient transport facilities in the public health care system becomes crucial in such a scenario.[7] Strengthening the primary care setting to manage more uncomplicated cases and organizing a prompt referral system are required to address the issue of rural neonatal mortality appropriately.

The leading causes of neonatal mortality worldwide and in India are prematurity and related complications, birth asphyxia, and infections.[8,9] These are among the most common causes of NICU admissions.[7] Prompt identification and timely intervention using disease severity scoring systems can reduce mortality.[10] Several scoring systems have been used to study the outcomes of extramural newborns. The TOPS score uses vitals like temperature, oxygen level, pulse rate, and sugar levels to predict neonatal outcomes.[11] The MINT score considers variables like the APGAR score at 1 minute, birth weight, age, pH, arterial partial pressure of oxygen, heart rate, and congenital anomaly. The sick neonate score, developed by Rathod et al, is an adaptation of the Hermansen score.[12,13] It considers 7 parameters- respiratory efforts, heart rate, mean blood pressure, axillary temperature, capillary filling time, random blood sugar, and SpO_2. It has been studied exclusively in extramural neonates and effectively predicts mortality. This score is easy to apply and accounts for essential parameters like capillary refill time and blood pressure. The extended sick neonate score, studied by Ray et al included Moro's reflex and modified Downe's score.[14] It was more complex to calculate but had the highest specificity when compared to the SNS and the score for neonatal acute physiology – perinatal extension II (SNAPPE-II) (albeit it was the least sensitive of the three).[6] The modified sick neonate score (MSNS), developed by Mansoor et al is another adaptation of the sick neonate score, where we use the birth weight and gestational age instead of mean blood pressure.[15]

The previous scores only focused on out born neonates, while MSNS can also be applied to intramural neonates. Studying extramural babies in the context of intramural ones can highlight potential problem areas. A standardized scoring system provides a larger, more diverse sample to study outcomes and can be used for quality improvement within the NICU. It can also be used to compare the performance of different newborn care units. Since it does not require invasive monitoring, it can be used by paramedical and medical staff in low-resource settings. Since it considers two critical factors of birth weight and gestational age, we can get an accurate measure of the overall patient status. A study conducted by Rathi et al showed that out born babies admitted after 6 hours of birth required higher amounts of critical care support (vasopressor and oxygen support), and an objective scoring system like the MSNS could guide the management for this group of patients.[16] As discussed above, this kind of standardized scoring system could help establish guidelines regarding management at different levels and improve neonatal care in a developing healthcare system like ours. This study uses the MSNS to compare the NICU outcomes of intramural and extramural neonates at a tertiary care center.

METHODS

This prospective analytical study was conducted at the NICU of GMERS General Hospital and Medical College, Vadodara. The study period was from April 2020 to December 2021. Data from a convenience sample of 420 neonates was recorded on a semi-structured proforma with the approval of the IRB and ethics committee. Informed consent was obtained from the parents of the neonates enrolled in the study. Basic demographic details like the place of birth, gender, and cause of admission were recorded in addition to the 8 parameters of the MSNS. These parameters are routinely recorded as a part of the newborn special neonatal care unit (SNCU) assessment, with the details recorded within 8 hours of admission. A total modified sick neonatal score was assigned based on the sum of the individual parameters. The patients were followed till the end of their NICU stay and the outcome was defined in terms of discharge or death. Neonates with conditions incompatible with life, were referred to another center from our NICU, or took leave against medical advice were excluded from the sample. Neonates who had exceeded the 8-hour time limit for data collection were also excluded to avoid the stabilization effect in the NICU.

Criteria were the same for inborn and outborn neonates. The scoring system parameters and score distribution are mentioned in Table 1.

Table 1: Parameters of MSNS with the scoring for each parameter.

Parameter	0	1	2
Respiratory effort (/min)	Apnea or grunt	Tachypnoea (respiratory rate >60)	Normal (respiratory rate 40-60/min)
Heart rate(/min)	Bradycardia/asystole	Tachycardia (>160/min)	Normal (100-160/min)
Axillary temperature (°C)	<36	36-36.5	36.5-37.5
Capillary refilling time (s)	>5	3-5	<3
SpO2 (in % on room air)	<85	85-92	>92
Random blood sugar (mg/dl)	<40	40-60	>60

Continued.

Parameter	0	1	2
Gestational age (in weeks)	<32	32-36 weeks+6 days	37 weeks
Birth weight (kg)	<1.5	1.5-2.49	2.5
Total	Maximum -		16

Statistical analysis

The data was entered into a Microsoft excel spreadsheet, and the final analysis was done using statistical package for social sciences (SPSS) software, IBM manufacturer, Chicago, USA, version 25.0. Categorical variables were presented as numbers and percentages (%), while the quantitative data with non-normal distribution were presented as median with 25th and 75th percentiles (interquartile range). The Kolmogorov-Smirnov test was used to check the data normality. In cases where the data was not standard, we used nonparametric tests. The association of the variables, which were quantitative and not generally distributed in nature, was analysed using Mann-Whitney test. The association of the qualitative variables was analyzed using the Chi-square test. Fisher's exact test was used if any cell had an expected value of less than 5. The receiver operating characteristic curve was used to find the cut-off point, sensitivity, specificity, positive predictive value, and negative predictive value of the total score for predicting mortality. A p value of less than 0.05 was considered statistically significant for the purpose of this study.

RESULTS

10 out of the 420 neonates considered for the study were excluded. Table 2 depicts the baseline characteristics of the neonates. 181 neonates were born at our institution, and 229 were referred from other institutions/came from home. This contrasted with several studies and could be explained by the better prognosis of inborn neonates at birth, lowering their need for intensive care.[16,17] GMERS Hospital, Gotri, Vadodara, was also the designated COVID facility for the district during the study. This could have impacted the number of deliveries occurring and thus reduced the number of inborn neonates requiring NICU admissions. Jaysheel et al had a similar distribution of intramural and extramural neonates. 51.46% of the neonates were preterm (less than 36 weeks of gestation), and 48.54% were born at term. 88.54% of the sample had a good outcome (was discharged), and 11.46% of the newborns did not survive. 5% of inborn babies had poor outcomes, whereas mortality was higher for out born newborns at 16%, which falls in the range (2% to 19%) of mortality rates in SNCUs nationwide.[18] The mean duration of admission was 4.39 days, with a median stay of 3 days (IQR 2-5). Inborn and out born babies stayed in the NICU for almost the same duration (4.37 and 4.39 days, respectively), possibly due to a shorter stay due to early deaths in neonates with poorer outcomes. Overall, the leading causes of admission were prematurity and related complications, birth asphyxia, and neonatal hyperbilirubinemia. These findings correlate with the global trends in NICU admission.[8,9] The leading causes of admission for inborn newborns were prematurity and related complications (40.88%) and neonatal hyperbilirubinemia (15.47%), among others, the same as the overall trend for our study. Most outborn neonates were admitted for prematurity-related complications (51.09%), and a higher percentage of outborns were admitted for birth asphyxia (13.54%) compared to inborn babies (9.39%). 5.36% (n=22) of the neonates were admitted for observation due to maternal conditions- 11 babies in this group were delivered to mothers with COVID-19 infection and were all discharged successfully. Table 3 demonstrates the distribution of MSNS parameters among the intramural and extramural neonates.

Mann-Whitney test was applied to determine the differences in the individual parameters, with the difference in oxygen saturation having the strongest association. Outborn neonates were found to have lower scores in the categories of axillary temperature and gestational age. Rathod et al also showed that axillary temperature demonstrated the strongest association with poor outcomes in SNS.[12] The difference in respiratory effort between inborn and outborn neonates was not significant, possibly due to pre-transport stabilization.

Table 2: Baseline characteristics of neonates' distribution.

Baseline characteristics of neonates	Frequency	Percentage
Gestational age		
Preterm	211	51.46
Term	199	48.54
Birth weight		
<1.5	85	20.73
1.5 to 2.49	196	47.80
2.5 or above	129	31.46
Gender		
Female	186	45.37
Male	224	54.63
Place of birth		
Inborn	181	44.15
Outborn	229	55.85
Outcome		
Discharged	363	88.54
Expired	47	11.46

Neonates that were referred from other institutions were found to have lower mean scores (12) as compared to the inborn neonates (13) at p<0.001. The mean MSNS for all the discharged newborns was higher than that for expired neonates (12 and 9, respectively), with the difference being statistically significant. The ROC curve generated with MSNS as a variable to predict neonatal mortality is shown in Figure 1 and Table 4; AUC was 0.859 (95% CI: 0.822 to 0.891). Considering an optimal cut-off of <11, the MSNS has a sensitivity of 85.11% and a specificity of 75.76% in predicting neonatal outcomes. The score was associated with a positive predictive value of 31.2% and a negative predictive value of 97.5%, with an accuracy of 76.83%. Our study demonstrates that the higher the score (when recorded within 8 hours of admission), the better the outcomes of neonates.

Table 3: Association of parameter of MSNS with inborn/outborn.

Parameter of MSNS	Inborn (n=181) (%)	Outborn (n=229) (%)	Total (%)	P value
Cause of admission				
Prematurity and related complications	74 (40.88)	117 (51.09)	191 (46.59)	<0.0001*
Sepsis	4 (2.21)	11 (4.80)	15 (3.66)	
Respiratory distress syndrome	5 (2.76)	11 (4.80)	16 (3.90)	
Birth asphyxia	17 (9.39)	31 (13.54)	48 (11.71)	
Neonatal hyperbilirubinemia	28 (15.47)	15 (6.55)	43 (10.49)	
Meconium Aspiration syndrome	8 (4.42)	1 (0.44)	9 (2.20)	
Convulsions	1 (0.55)	2 (0.87)	3 (0.73)	
Feeding difficulties	3 (1.66)	13 (5.68)	16 (3.90)	
Low birth weight	13 (7.18)	11 (4.80)	24 (5.85)	
Observation for maternal conditions	7 (3.87)	4 (1.75)	11 (2.68)	
Congenital malformations	2 (1.10)	6 (2.62)	8 (1.95)	
IUGR	6 (3.31)	1 (0.44)	7 (1.71)	
Transient tachypnea of the newborn	4 (2.21)	3 (1.31)	7 (1.71)	
Baby of covid positive mother	9 (4.97)	2 (0.87)	11 (2.68)	
Hypoxic ischemic encephalopathy (HIE)	0 (0)	1 (0.44)	1 (0.24)	
Respiratory effort				
Apnea or grunt	13 (7.18)	16 (6.99)	29 (7.07)	0.773†
Tachypnea (respiratory rate >60/min) with or without retractions	51 (28.18)	72 (31.44)	123 (30)	
Normal (respiratory rate 40-60/min)	117 (64.64)	141 (61.57)	258 (62.93)	
Heart rate				
Bradycardia or asystole	1 (0.55)	8 (3.49)	9 (2.20)	0.002*
Tachycardia (>160/min)	5 (2.76)	22 (9.61)	27 (6.59)	
Normal (100-160/min)	175 (96.69)	199 (86.90)	374 (91.22)	
Axillary temperature (°C)				
<36	7 (3.87)	27 (11.79)	34 (8.29)	0.012†
36 to 36.5	73 (40.33)	92 (40.17)	165 (40.24)	
36.5 to 37.5	101 (55.80)	110 (48.03)	211 (51.46)	
Capillary refill time (seconds)				
>5	1 (0.55)	6 (2.62)	7 (1.71)	0.033*
3 to 5	7 (3.87)	20 (8.73)	27 (6.59)	
<3	173 (95.58)	203 (88.65)	376 (91.71)	
SpO_2 (%)				
<85	17 (9.39)	45 (19.65)	62 (15.12)	0.0003†
85 to 92	34 (18.78)	63 (27.51)	97 (23.66)	
>92	130 (71.82)	121 (52.84)	251 (61.22)	
Random blood sugar (mg/dl)				
<40	5 (2.76)	20 (8.73)	25 (6.10)	0.039†
40 to 60	44 (24.31)	48 (20.96)	92 (22.44)	
>60	132 (72.93)	161 (70.31)	293 (71.46)	
Birth weight (kg)				
<1.5	31 (17.13)	54 (23.58)	85 (20.73)	0.065†
1.5 to 2.49	83 (45.86)	113 (49.34)	196 (47.80)	
2.5 or above	67 (37.02)	62 (27.07)	129 (31.46)	

Continued.

Parameter of MSNS	Inborn (n=181) (%)	Outborn (n=229) (%)	Total (%)	P value
Gestational age (weeks)				
<32 weeks	16 (8.84)	26 (11.35)	42 (10.24)	
32 to 36 weeks+6/7 days	62 (34.25)	107 (46.72)	169 (41.22)	0.01†
37 weeks and above	103 (56.91)	96 (41.92)	199 (48.54)	

*Fisher's exact test, †Chi square test

Table 4: Receiver operating characteristic curve of total score for predicting mortality.

Variables	Values
Area under the ROC curve (AUC)	0.859
Standard error	0.0301
95% confidence interval	0.822 to 0.891
P value	<0.0001
Cut off	≤11
Sensitivity (95% CI)	85.11 (71.7-93.8)
Specificity (95% CI)	75.76 (71.0-80.1)
PPV (95% CI)	31.2 (23.4-40.0)
NPV (95% CI)	97.5 (95.0-99.0)
Diagnostic accuracy	76.83

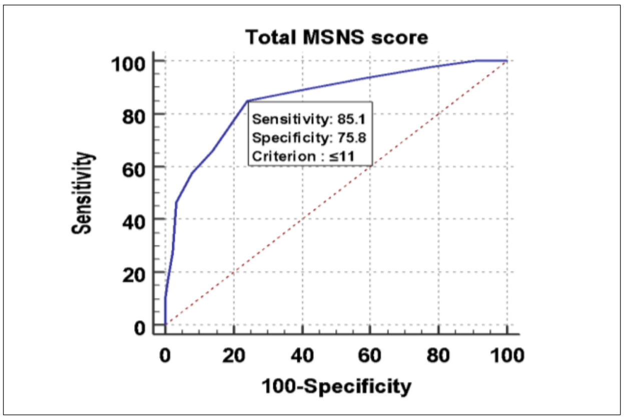

Figure 1: Receiver operating characteristic curve of total score for predicting mortality.

DISCUSSION

Our findings indicate that the MSNS effectively predicts mortality among intramural and extramural neonates. Previous iterations of the score, the sick neonate score and the extended sick neonate score were studied to predict mortality in babies transported to a facility.[12,14] MSNS helped us apply the same scoring system to inborn and out born neonates, showing that inborn babies tend to have higher scores and better outcomes than out born babies. An efficient transport system is of utmost importance in a country where most births occur in the peripheral areas. Several studies have demonstrated the changes in neonatal physiology. Mondal et al commented on the lack of pre-transport counselling and failure to record vitals as indicators of the current level of transport care.[19] The use of scoring systems can fix this aspect. MSNS was 85.11% sensitive and 75.76% specific at a cut-off of >11 (p<0.0001) in predicting neonatal outcomes. This is comparable to the findings of Mansoor et Al. in their study on MSNS.[15] They reported a positive predictive value of 31.2% and a negative predictive value of 97.5% with an accuracy of 76.83%. The area under the ROC curve generated was 0.859 (95% CI: 0.822 to 0.891). MSNS was more sensitive and specific at predicting mortality than the original SNS, with Rathod et Al. reporting a sensitivity of 58.3% and specificity of 52.7% at a cut-off of >8.[12] Ray et al found ESNS to be more sensitive and specific than MSNS at a cut-off of >11.[14] Modified ESNS, which combined MSNS and ESNS, had higher scores for both discharged and expired groups but was less sensitive than using MSNS alone.[22]

Several scoring systems have been used in neonates transferred to other facilities. Scores like TOPS, MINT, and SNS are relatively easy to use and have yielded significant results in outcome prediction. Mathur et al showed that all components of TOPS correlated with fatality, with a sensitivity of 81.6%, specificity of 77.93%, and AUC for derangement of more than two parameters as 0.89; findings comparable to ours.[20] In another study, oxygen saturation was found to be statistically significant in both pre- and post-transport TOPS scores, which was noted in our post-transport MSNS and reinforces the importance of maintaining oxygen saturations during transport.[21] This can influence our mode of transport since continuous monitoring is possible only in well-equipped ambulances. Several studies have also recommended the need for a specialized pediatric transport team, which might be challenging to achieve in the current circumstances due to the need for more trained personnel.[23] For longer transits associated with higher risk we could train the transport staff to use predictive scores like MSNS, enabling them to record the condition and act in case of acute changes in the parameters.[24] MSNS can facilitate communication at all points during the transfer-in counselling parents regarding prognosis in the pre-transport period, facilitating monitoring during transport, and enhancing inter-facility communication. In their study on the MINT score, Broughton et al demonstrated that this type of pre-transport communication can improve neonatal outcomes.[25]

Our study found that oxygen saturation, axillary temperature, and gestational age strongly correlated with poorer outcomes in extramural neonates. Hypothermia is one of the most encountered problems in out born neonates, and our findings show the need for better temperature control and monitoring during transport.

Hypoglycemia was found to be another category where more extramural neonates seemed to have lower scores. Information on stabilization techniques before and during transport was not available for our study. It is also to be seen how the MSNS changes during transport, and comparing pre- and post-transport scores will help determine its utility as a transport score.

While our study provided good results, it had its own limitations in terms of the score parameters as well as the application of the score. Since the sample only included patients from a single center, a multi-center study is required to validate the efficiency of the score across different systems. The MSNS system does not take maternal conditions like diabetes, bleeding disorders, obstetric complications, and infections into consideration. These can affect the growth of the neonates and, in turn, their postnatal outcomes. We also should have considered the day of life on admission and the mode of transport to the facility- both might have a role in the relatively poor outcomes displayed by the extramural group. In their study on MSNS, Mansoor et al commented that while most referred newborns were admitted on the first day of life, the mean day of life at admission was 2.58, making some of the referred neonates relatively older at the time of assessment.[15] The impact of this finding on their outcomes needs to be studied. Information on the mode of transport would also have helped provide recommendations regarding the use of ambulances or personal vehicles, increasing our study's clinical relevance. Further studies on the role of pre- and post-transport MSNS and repeated MSNS score evaluation need to be conducted. This will help us determine if the score needs to be updated regularly in the same admission to predict outcomes more accurately as the patient's condition progresses. MSNS is an efficient scoring system that can be applied to compare the outcomes of newborns in an intensive care setting, we need further studies to examine the extent of this application.

CONCLUSION

In conclusion, the MSNS can effectively predict outcomes in intramural and extramural babies, with the range being higher for inborn babies- indicating a better prognosis. The score can be applied at all points during transport for identification and prompt action. It can provide a prognosis to the family and facilitate inter-facility communication. We can apply this score to all babies and prioritize the allocation of procedures, ventilators, and other such medical services to admitted neonates. Its ease of application and use of non-invasive parameters have the potential to prevent neonatal mortality and improve neonatal care in resource-limited settings.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Naithani K, Tripathi S, Trivedi H, Pandya NK. Comparing neonatal intensive care unit outcomes of intramural and extramural neonates using the modified sick neonate score. Int J Contemp Pediatr 2023;10:1507-13.