# Association between Transport Risk Index of Physiologic Stability in Extremely Premature Infants and Mortality or Neurodevelopmental Impairment at 18 to 24 Months

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**Objectives** To examine the association between mortality or neurodevelopmental impairment at 18-24 months of corrected age and the Transport Risk Index of Physiologic Stability (TRIPS) score on admission to the neonatal intensive care unit (NICU) in extremely premature infants.

**Study design** Retrospective cohort study of extremely premature infants (inborn and outborn) born at 22-28 weeks of gestational age and admitted to NICUs in the Canadian Neonatal Network between April 2009 and September 2011. TRIPS scores and clinical data were collected from the Canadian Neonatal Network database. Follow-up data at 18-24 months of corrected age were retrieved from the Canadian Neonatal Follow-Up Network database. Neurodevelopment was assessed using the Bayley Scales of Infant and Toddler Development, Edition III. The primary outcome was death or significant neurodevelopmental impairment at 18-24 months of corrected age. The secondary outcomes were individual components of the Bayley Scales of Infant and Toddler Development, Edition III assessment.

**Results** A total of 1686 eligible infants were included. A TRIPS score of ≥20 on admission to the NICU was significantly associated with mortality (aOR 2.71 [95% CI, 2.02-3.62]) and mortality or significant neurodevelopmental impairment (aOR 1.91 [95% CI, 1.52-2.41]) at 18-24 months of corrected age across all gestational age groups of extremely premature infants.

**Conclusion** The TRIPS score on admission to the NICU can be used as an adjunctive, objective tool for counselling the parents of extremely premature infants early after their admission to the NICU. *(J Pediatr 2020;224:51-6)*.

Risk stratification and prognostication of neurodevelopmental outcomes are of increasing importance in neonatal care and for counselling parents. Risk assessment tools for neonatal illness severity include the Clinical Risk Index for Babies (CRIB) and CRIB-II, the Score for Neonatal Acute Physiology (SNAP) and SNAP-II, and the Transport Risk Index of Physiologic Stability (TRIPS) and TRIPS-II.[1-7] The TRIPS score is based on physiology and includes 4 empirically weighted items: temperature, blood pressure, respiratory status, and response to noxious stimuli.[6] These items represent 4 crucial physiologic systems: thermoregulation, hemodynamics, respiratory status, and neurology.

TRIPS is a validated assessment tool for outborn infants in neonatal transport.[6] TRIPS-II is a benchmark tool for short-term illness severity and is validated for 7-day mortality and overall mortality during hospitalization in the neonatal intensive care unit (NICU).[7] As neonatal survival rates continue to increase, the clinical focus shifts to improving neurodevelopmental outcomes; however, most neonatal illness scoring systems have not been correlated with neurodevelopmental outcomes. Because outcome assessment can only be done over the course of time for a growing child, early prognostication tools are needed for counselling families in the NICU.

We hypothesized that the TRIPS score on admission to the NICU would be associated with mortality, neurodevelopmental impairment (NDI), and significant NDI at 18-24 months of corrected age.

## Methods

This was a retrospective cohort study using data from the Canadian Neonatal Network (CNN) and follow-up data from the Canadian Neonatal Follow-Up

| | |
|---|---|
| Bayley III | Bayley Scales of Infants and Toddler Development |
| CNN | Canadian Neonatal Network |
| CNFUN | Canadian Neonatal Follow-Up Network |
| CRIB | Clinical Risk Index for Babies |
| NDI | Neurodevelopmental impairment |
| NICU | Neonatal intensive care unit |
| SNAP | Score for Neonatal Acute Physiology |
| TRIPS | Transport Risk Index of Physiologic Stability |

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*A list of additional investigators of the Canadian Neonatal Network (CNN) and Canadian Neonatal Follow-Up Network (CNFUN) are listed available at www.jpeds.com (**Appendix**).

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Network (CNFUN) database. The data collected from the CNN and CNFUN databases, including neonatal short-term and long-term outcomes and infant and maternal characteristics, are listed in data collection section.

The CNN was established in 1995 and is a collaborative research group focused on improving neonatal outcomes and health care. Currently, 30 (out of 31) Canadian NICUs participate in the CNN. The network maintains a standardized NICU admissions database that is used for a wide range of research aimed at decreasing mortality and significant morbidity in NICU patients through better practices.

We included all extremely premature infants (inborn and outborn infants) with a gestational age of 22-28 weeks who were admitted to NICUs participating in the CNN between April 1, 2009, and September 30, 2011, who had a TRIPS score (temperature, blood pressure, respiratory status, and response to noxious stimuli; **Table I** [available at www.jpeds.com]) on admission and a Bayley Scales of Infants and Toddler Development (Bayley III) assessment at 18-24 months of corrected age.[6,8] Exclusion criteria were major congenital anomalies, palliation offered immediately on admission (moribund infant), missing information on TRIPS score, or missing information for the neurodevelopmental assessment. Neurodevelopment was assessed using the Bayley III.[8]

### Primary and Secondary Outcomes

The primary outcome was death or significant NDI at 18-24 months of corrected age. We defined significant NDI as cerebral palsy with Gross Motor Function Classification System score of ≥3; Bayley III motor, language, cognitive, or general adaptive composite scores of <70; need for hearing aids or cochlear implant; bilateral visual impairment; or significant developmental delay that precluded using the Bayley III for assessment.[9] NDI was defined as cerebral palsy with a Gross Motor Function Classification System score of ≥1, any Bayley III component score of <85, sensorineural or mixed hearing loss, unilateral or bilateral visual impairment, or developmental delay that precluded using the Bayley III for assessment. The category of NDI included infants with significant NDI. The secondary outcomes were the individual components of Bayley III assessment: language, cognitive, and motor scores. The composite outcome was defined as any mortality or significant NDI or any Bayley III composite score of <85.

The TRIPS score consisted of four physiologic variables: temperature, blood pressure, respiratory status, and response to noxious stimuli upon initial admission to the NICU, as defined in the original TRIPS publication (**Table I**).[6] All study variables on neonatal short-term and long-term outcomes and infant and maternal characteristics were in agreement with the definitions of the CNN Abstractor's Manual and the CNFUN manual.[10,11]

### Statistical Analyses

Approximately 1500 extremely premature infants (gestational age of 22-28 weeks) are admitted to NICUs in the CNN per calendar year. Because no previous relevant studies or other relevant preliminary information were available for sample size estimation, we included all eligible neonates admitted to NICUs in the CNN between April 2009 and September 2011 who were followed up and admitted in the CNFUN database.

The study population was summarized using descriptive statistical methods and compared with the population of infants excluded owing to a missing TRIPS score at admission, to assess the similarity of the 2 populations. Infants in our study population were first categorized based on their TRIPS score at admission into 5 ordinal groups with 10-unit increments from <10 to ≥40. To examine the association between infant characteristics and TRIPS score at admission, the infant characteristics were compared among the 5 TRIPS score groups using the $\chi^2$ test. To examine the expected positive relationship between the TRIPS score at admission and the outcomes, trends in the rates of outcomes across the ordinal TRIPS score groups were tested using the Cochran-Armitage trend test.

We further examined the effect of TRIPS score on the outcomes using multiple logistic regression models adjusted for the potential confounders identified in the univariate analysis. To account for interaction effect of TRIPS score and gestational age, we further determined the effect of TRIPS score on the outcomes for each gestational age group and applied similar multiple logistic regression models, but with an additional interaction term between TRIPS score and gestational age group. We also identified a cut-off of 20 in TRIPS score based on the change point of the percent change in the primary outcome across the ordinal TRIPS score groups. The associations between the outcomes and TRIPS score of ≥20 were examined using the $\chi^2$ test. Multiple logistic regression models with an interaction term between a TRIPS score of ≥20 and gestational age group were further applied to determine the impact of a TRIPS score of ≥20 on the outcomes for each gestational age group, adjusted for potential confounders. Data management and statistical analyses were performed using SAS 9.4 (SAS Institute, Inc, Cary, North Carolina). A 2-sided $P$ value of <.05 was used to determine statistical significance.

Data collection, evaluation, and publication for this study were approved by the Research Ethics Board (REB) at Mount Sinai Hospital, Toronto, Canada (REB file number: 18-0268-C).

## Results

There were 3261 infants born at 22-28 weeks of gestational age and admitted to NICUs in the CNN between April 1, 2009, and September 30, 2011, who either had neurodevelopmental assessments performed at 18-24 months of corrected age or died before the assessments. Of these, 237 infants were moribund (n = 98) or had a major congenital anomaly (n = 139) and were excluded. We also excluded an additional 1338 infants with missing TRIPS scores. The study population included the 1686 remaining infants (**Figure 1**; available at www.jpeds.com). To assess possible selection

bias affecting our study population, we compared infant characteristics between our study population and the infants excluded owing to missing TRIPS scores (**Table II**; available at www.jpeds.com). No differences between the 2 populations were observed, suggesting that excluding infants with missing TRIPS scores was unlikely to introduce selection bias.

Maternal, pregnancy, and neonatal characteristics in the overall cohort and according to TRIPS score category are reported in **Table III** (available at www.jpeds.com). High TRIPS scores were significantly associated with younger gestational age, lower birth weight, outborn status, Apgar score of <7 at 5 minutes of age, and less use of antenatal steroids.

**Table IV** (available at www.jpeds.com) shows the associations between the primary, secondary, and composite outcomes and the TRIPS score. Overall mortality in our cohort was 325 of 1686 (19.3%), including mortality after discharge from the NICU, which was 29 of 1686 (1.7%). Rates of the adverse neurodevelopmental outcomes were significantly increased with increasing TRIPS scores (**Table IV** and **Figure 2**; all outcomes $P < .05$, except for Bayley III language composite: $P = .12$).

We examined the aOR of outcomes per 10 unit TRIPS score increase, adjusted for the potential confounders identified in the univariate analysis. The aORs for the composite outcome (per 10-unit increase in TRIPS score) were 1.96 (95% CI, 1.09-3.51) and 1.35 (95% CI, 1.19-1.55) for infants in the gestational age groups of 22-23 weeks and 24-26 weeks, indicating that the odds of the adverse composite outcome increased by 96% (95% CI, 1.96-1.00) and 35% (95% CI, 1.35-1.00), respectively. These results are presented in **Table V** and **Figure 3** (**Figure 3** available at www.jpeds.com).

Starting from a TRIPS score of 20, there was no change in the percent rate of change in the composite outcome compared with the first TRIPS score group of <10. Therefore, we examined the effect of a TRIPS score of ≥20 on the outcomes: Results from both univariate and multivariable analyses are shown in **Table VI**. The results showed that a TRIPS score of ≥20 was associated with a higher risk of adverse neurodevelopmental outcome, and this was most pronounced in the 24-26 weeks gestational age group (**Table VI**, **Figure 4**, and **Figure 5** [**Figure 5** available at www.jpeds.com]).

## Discussion

A TRIPS score on admission to the NICU in extremely premature infants of 22-28 weeks of gestational age was associated with mortality and NDI at 18-24 months of corrected age. Higher TRIPS scores reflect higher degrees of physiological instability and were associated with increased risk for significant NDI and mortality. In our cohort, a TRIPS score ≥20 was associated with adverse outcomes in all gestational age groups and therefore, the TRIPS score can supplement risk assessment based on gestational age.

We reported differences in the strength of the association between high TRIPS scores and neurodevelopmental outcomes across the different gestational age groups. We believe that the weaker association in the lowest gestational age group (22-23 weeks) may be due to overall high mortality rate and the much smaller number of infants in the 22-23 week group. Our results showed the most significant association in the middle gestational age group (24-26 weeks of gestation). This finding is important because although this particular group of extremely premature infants is still at high risk for death or significant NDI, they seem to benefit most from high-quality neonatal care. Extremely premature infants born at >26 weeks of gestation have an overall lower risk of adverse outcomes.

Our findings are important because the focus of neonatal care has shifted to increasing rates of favorable neurodevelopmental outcomes instead of simply reducing mortality. Our study population confirmed an overall mortality rate of 19.3%. We acknowledge that mortality may seem to be an important driver in the exposure-outcome relationship in the whole study population. However, this may not be true in those infants surviving

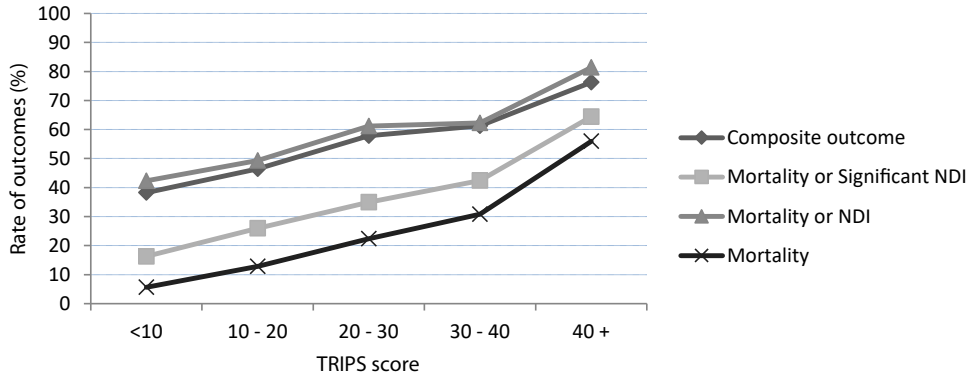


**Figure 2.** Association between outcomes and TRIPS score.

**Table V. Association between outcomes and TRIPS score**

| Outcomes | Gestational age groups | | | |
|---|---|---|---|---|
| | All (n = 1686)* | 22-23 weeks (n = 93)† | 24-26 weeks (n = 822)† | 27-28 weeks (n = 771)† |
| Composite outcome | 1.26 (1.15-1.39) | 1.96 (1.09-3.51) | 1.35 (1.19-1.55) | 1.14 (0.99-1.30) |
| Mortality or significant NDI | 1.37 (1.24-1.53) | 2.35 (1.39-3.99) | 1.40 (1.23-1.61) | 1.27 (1.08-1.51) |
| Mortality or NDI | 1.25 (1.14-1.37) | 1.96 (1.09-3.51) | 1.38 (1.20-1.58) | 1.10 (0.97-1.26) |
| Mortality or Bayley III composite outcome | 1.24 (1.13-1.37) | 1.75 (1.03-2.97) | 1.33 (1.17-1.52) | 1.13 (0.99-1.29) |
| Mortality | 1.68 (1.48-1.91) | 2.84 (1.73-4.67) | 1.53 (1.31-1.79) | 1.80 (1.41-2.30) |
| Infants survived at discharge from NICU: | | | | |
| Composite outcome | 1.11 (1.001-1.23) | 1.23 (0.62-2.46) | 1.19 (1.02-1.38) | 1.02 (0.88-1.17) |
| Mortality or Significant NDI | 1.10 (0.96-1.26) | 1.57 (0.80-3.08) | 1.16 (0.97-1.39) | 0.97 (0.78-1.20) |
| Mortality or NDI | 1.10 (0.996-1.22) | 1.23 (0.62-2.46) | 1.22 (1.05-1.41) | 0.99 (0.86-1.14) |
| Mortality or Bayley III composite outcome | 1.09 (0.98-1.21) | 1.03 (0.53-1.98) | 1.16 (1.002-1.34) | 1.00 (0.87-1.16) |
| Significant NDI | 1.11 (0.96-1.27) | 1.57 (0.80-3.08) | 1.17 (0.97-1.40) | 0.97 (0.78-1.20) |
| NDI | 1.11 (1.001-1.23) | 1.23 (0.62-2.46) | 1.22 (1.05-1.42) | 0.99 (0.86-1.14) |
| Bayley III composite outcome | 1.08 (0.97-1.20) | 0.60 (0.24-1.52) | 1.14 (0.98-1.34) | 1.01 (0.87-1.17) |
| Bayley III language composite score <85 at 18-24 months | 1.04 (0.93-1.17) | 0.64 (0.25-1.58) | 1.07 (0.91-1.25) | 1.01 (0.86-1.19) |
| Bayley III cognitive composite score <85 at 18-24 months | 1.16 (0.99-1.35) | 0.54 (0.21-1.43) | 1.25 (1.02-1.53) | 1.05 (0.83-1.34) |
| Bayley III motor composite score <85 at 18-24 months | 1.13 (0.99-1.29) | 0.53 (0.21-1.38) | 1.17 (0.98-1.41) | 1.12 (0.91-1.37) |

Values are aOR (95% CI) per 10 unit increase in TRIPS.
*aOR (all) = aOR determined based on the multivariable logistic regression model adjusted for gestational age, outborn status, and antenatal steroid use.
†aOR (gestational age group) = aOR determined based on the multivariable logistic regression model with interaction term between gestational age group and TRIPS score, adjusted for gestational age, outborn status, and antenatal steroid use. The Apgar score at 5 minutes was not included for adjustment because both Apgar score and TRIPS score are measurements of sickness.

until discharge from the NICUs as very few infants (1.7%) died after discharge and the association between TRIPS scores of ≥20 and NDIs persisted in infants born at 24-26 weeks of gestational age. Optimizing neurodevelopmental outcomes has become an essential focus and measure of quality in neonatology.

TRIPS is a risk-weighted score based on physiologic variables at NICU admission.[6] These assessments are practical, user-friendly, easy to obtain within 1 minute, do not need laboratory or technical equipment, and can be used sequentially to revise outcome predictions. These characteristics confer important advantages over other existing illness

**Table VI. Association between outcomes and TRIPS score <20 vs TRIPS score ≥20**

| Outcomes | TRIPS score group | | | AOR (95% CI) (TRIPS score ≥20 vs <20) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Gestational age group | | | |
| | <20 | ≥20 | *P* value* | All (n = 1686)† | 22-23 (n = 93)‡ | 24-26 (n = 822)‡ | 27- 28 (n = 771)‡ |
| Composite outcome | 43.42 (376/866) | 60.85 (499/820) | <.0001 | 1.72 (1.40-2.12) | 2.67 (0.80-8.94) | 2.05 (1.54-2.74) | 1.35 (1.0-1.83) |
| Mortality or significant NDI | 22.4 (194/866) | 40.73 (334/820) | <.0001 | 1.91 (1.52-2.41) | 3.75 (1.31-10.71) | 2.16 (1.60-2.91) | 1.44 (0.98-2.10) |
| Mortality or NDI | 46.77 (405/866) | 63.17 (518/820) | <.0001 | 1.68 (1.36-2.07) | 2.67 (0.80-8.93) | 2.03 (1.52-2.72) | 1.30 (0.97-1.75) |
| Mortality or Bayley III composite outcome | 42.26 (366/866) | 59.02 (484/820) | <.0001 | 1.67 (1.35-2.05) | 2.83 (0.90-8.89) | 1.94 (1.45-2.58) | 1.33 (0.98-1.80) |
| Mortality | 10.16 (88/866) | 28.9 (237/820) | <.0001 | 2.71 (2.02-3.62) | 5.58 (2.03-15.3) | 2.35 (1.64-3.36) | 2.91 (1.67-5.06) |
| Infants survived at discharge from NICU | | | | | | | |
| Composite outcome | 37.9 (299/789) | 46.59 (280/601) | .001 | 1.37 (1.10-1.72) | 1.30 (0.34-5.05) | 1.64 (1.19-2.26) | 1.09 (0.79-1.51) |
| Mortality or Significant NDI | 14.83 (117/789) | 19.13 (115/601) | .033 | 1.29 (0.95-1.73) | 2.04 (0.55,7.62) | 1.60 (1.08-2.39) | 0.80 (0.49-1.31) |
| Mortality or NDI | 41.57 (328/789) | 49.75 (299/601) | .002 | 1.35 (1.08-1.69) | 1.30 (0.34-5.06) | 1.63 (1.18-2.24) | 1.06 (0.77-1.45) |
| Mortality or Bayley III composite outcome | 36.63 (289/789) | 44.09 (265/601) | .005 | 1.31 (1.04-1.64) | 1.38 (0.37-5.17) | 1.52 (1.11-2.10) | 1.06 (0.76-1.47) |
| Significant NDI | 14.85 (117/788) | 19.23 (115/598) | .03 | 1.29 (0.96-1.74) | 2.04 (0.55-7.61) | 1.61 (1.08-2.40) | 0.80 (0.49-1.32) |
| NDI | 41.62 (328/788) | 50 (299/598) | .002 | 1.36 (1.09-1.71) | 1.30 (0.34-5.06) | 1.64 (1.19-2.26) | 1.07 (0.78-1.47) |
| Bayley III composite outcome | 38.4 (278/724) | 45.32 (247/545) | .01 | 1.29 (1.02-1.64) | 0.45 (0.08-2.40) | 1.54 (1.10-2.15) | 1.06 (0.76-1.49) |
| Bayley III language composite score <85 at 18-24 months | 30.54 (241/789) | 35.77 (215/601) | .04 | 1.20 (0.94-1.54) | 0.56 (0.12-2.70) | 1.30 (0.92-1.83) | 1.06 (0.74-1.52) |
| Bayley III cognitive composite score <85 at 18-24 months | 11.89 (86/723) | 16.21 (88/543) | .028 | 1.40 (1.001-1.96) | 0.40 (0.08-2.03) | 1.89 (1.20-2.99) | 0.93 (0.54-1.61) |
| Bayley III motor composite score <85 at 18-24 months | 17.03 (117/687) | 22.83 (121/530) | .011 | 1.36 (1.01-1.83) | 0.31 (0.06-1.61) | 1.72 (1.15-2.58) | 1.11 (0.70-1.77) |

Adverse neurodevelopmental outcome: all variables listed as outcome, except Bayley III composite outcome and Bayley III language/cognitive/motor composite score <85.
*The reported *P* values were based on the comparisons between 2 groups using a $\chi^2$ test.
†aOR (all) = aOR determined based on the multivariable logistic regression model adjusted for gestational age, outborn status, and antenatal steroid use.
‡aOR (gestational age group) = aOR determined based on the multivariable logistic regression model with interaction term between gestational age group and TRIPS score, adjusted for gestational age, outborn status, and antenatal steroid use.

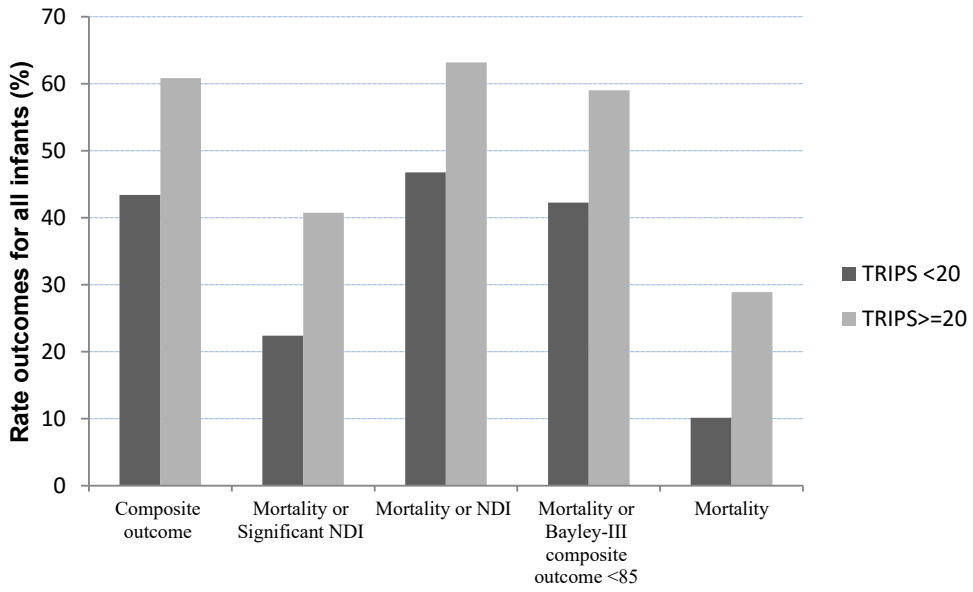


**Figure 4.** Association between outcomes and TRIPS score <20 vs TRIPS score ≥20.

severity scores, such as CRIB or SNAP, because they include neonatal demographic data (such as gestational age or birth weight), and physiologic assessments are obtained over the first 12-24 hours in the NICU.[2,4] Consequently, these scores might reflect interventions in the NICU instead of neonatal physiologic stability and may limit their informative value for describing illness severity on admission.

TRIPS has been used to assess short-term illness severity and is validated for the prediction of 7-day mortality.[7] The association of TRIPS score and neurodevelopmental outcomes has not been reported previously. Very few studies have investigated the association of other neonatal illness severity scores and neurodevelopmental outcomes.[12-15] The CRIB score was predictive of NDI at 18 months in univariate analysis, but not with multiple logistic regression. Adjusting CRIB score for gestational age might enhance its prognostic ability.[12] In a single-center Canadian cohort study from 2009, CRIB-II scores of ≥13 predicted significant NDI at 36 months with a sensitivity of 83% and a specificity of 84%.[3,13] In contrast with the CRIB score, CRIB-II score included far more precise subcategories for gestational age and birth weight, stratified by sex.

In the ELGAN study, SNAP-II scores of ≥30 also predicted mortality and unfavorable neurodevelopment at 24 months.[14] The association of high SNAP-II scores and NDI persisted at 10 years of age.[15] Comparing the more recent CRIB-II (2009) and SNAP-II (2010) populations to our TRIPS population, it is notable that the other studies of extremely premature infants <28 weeks of gestational age were born between 2000 and 2004 with a mean gestational age of 27 weeks.[13,14] In our TRIPS population, infants were born between 2009 and 2011 with a mean gestational age of 26 weeks, and one-quarter of the population was born at <26 weeks of gestational age. There is an increased risk for unfavorable neurodevelopmental outcomes in a cohort with a lower mean gestational age. Moreover, the cohorts from 2 different decades reflect different neonatal practices. For instance, antenatal steroids have become a standard of care. Neurodevelopmental assessment has also changed over time, using the Bayley II and then the Bayley III, with different cut-offs defining the NDI categories.

On one hand, full neonatal care is presently provided for smaller and sicker extremely premature infants, resulting in higher morbidities. On the other hand, improved obstetric and neonatal care has resulted in lower CRIB-II and SNAP-II scores.[16] The 2 time points compared by Groenendaal et al approximately reflect the time points of birth of neonates included in the early CRIB-II and SNAP-II neurodevelopment studies and those of the neonates in our TRIPS cohort.[13,14] Our proposed TRIPS cut-off for high risk of adverse neurodevelopmental outcomes is based on our preterm cohort of infants born around 2010. TRIPS was only introduced in 2001 and revised in 2013.[6,7] It is likely that cut-offs will need to be revalidated over time.

We included inborn and outborn infants in our study population, whereas all the SNAP studies included inborn infants only.[14] It would be interesting to investigate the effect of inborn/outborn status in a subsequent analysis of our data. For extremely premature infants requiring transportation to a tertiary level NICU, outborn status is well-known to increase the risk of NDI, partially owing to an increased risk of severe intraventricular hemorrhage.[17,18]

TRIPS is a physiology-based, true index of neonatal risk with minimal interobserver bias. In contrast with to the

CRIB and SNAP indices, all 4 TRIPS variables are modifiable. Further research may identify if TRIPS scores could be used as a reminder to improve neonatal care quickly to improve neurodevelopmental outcomes.

Adding additional TRIPS measurements at various time points, possibly even including neonatal morbidities, would deviate from the initial intention to associate risk early on based on fundamental physiologic function. It would rather reflect a measurement of quality of care received in the NICU. Moreover, TRIPS is associated with NDI before neonatal morbidity during the NICU stay and the effects of socioeconomic factors are considered. TRIPS could be used for early risk stratification and as a valuable adjunct for counselling parents of extremely premature infants within the first days of life. Infants with high TRIPS scores might warrant earlier follow-up of high risk and participate in early intervention programs.

Our observational study has several limitations. The data were analyzed retrospectively and the sample was limited by the availability of TRIPS scores and neurodevelopmental follow-up data at the age of 18-24 months. This factor could result in bias and is a common area of concern in outcomes research. We did not have sufficient data on intercurrent illness and other important health issues during the time period between discharge from the NICU and follow-up assessment. Furthermore, information on family socioeconomic status was not available. Neurodevelopmental assessments carried out until school age would be beneficial for evaluating more complex cognitive functions and behavioral and social skills, ideally even providing an estimate of performance in adult life.

We report a national, multicenter study of retrospectively collected data from a comparatively recent cohort with a high sample size of extremely premature infants (22-28 weeks gestational age). The TRIPS score has been validated in a Canadian cohort and might be biased by national guidelines and practices in neonatal care.

The simplicity of TRIPS makes it suitable for large international prospective studies, including developing countries where resources for technology- or laboratory-based measurements are lacking. Differences in TRIPS scores and neurodevelopmental outcomes between inborn and outborn extremely premature infants should be assessed separately. Furthermore, the aspect of timing of TRIPS scoring (eg, with a 1-minute APGAR score vs on admission to the NICU) is another research question that arises from our study.

TRIPS score on admission to the NICU is associated with mortality and neurodevelopmental outcomes of inborn and outborn extremely premature infants at 18-24 months of corrected age. ■

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## Data Statement

Data sharing statement available at www.jpeds.com.

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## Appendix

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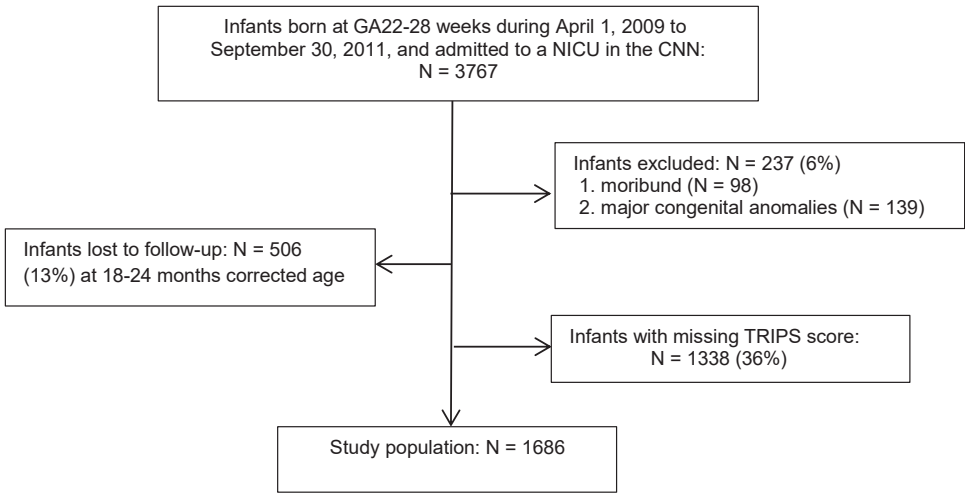


**Figure 1.** Study population.

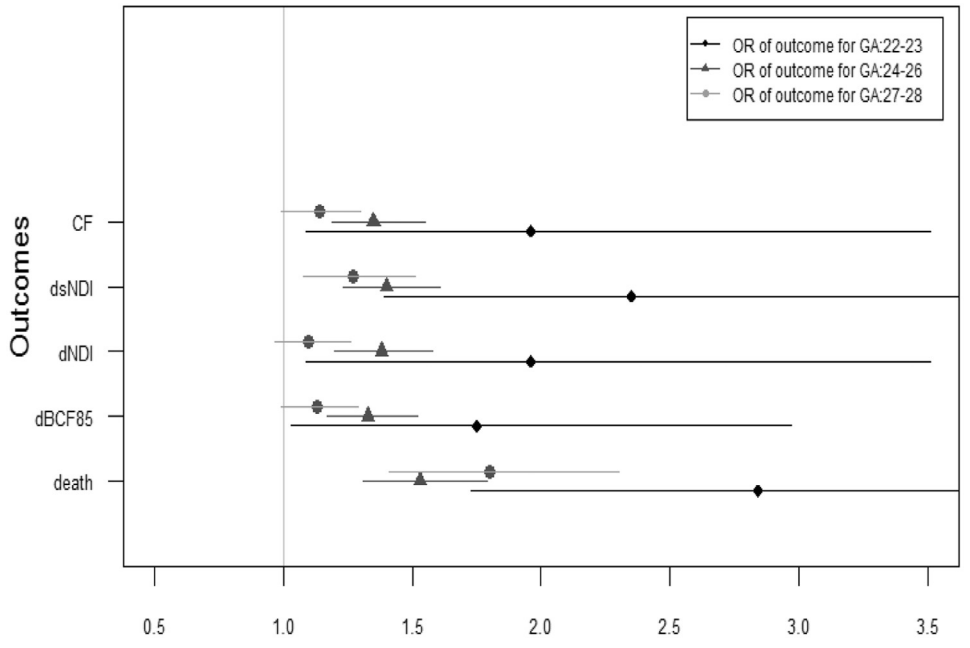


**Figure 3.** Association between outcomes and TRIPS score.

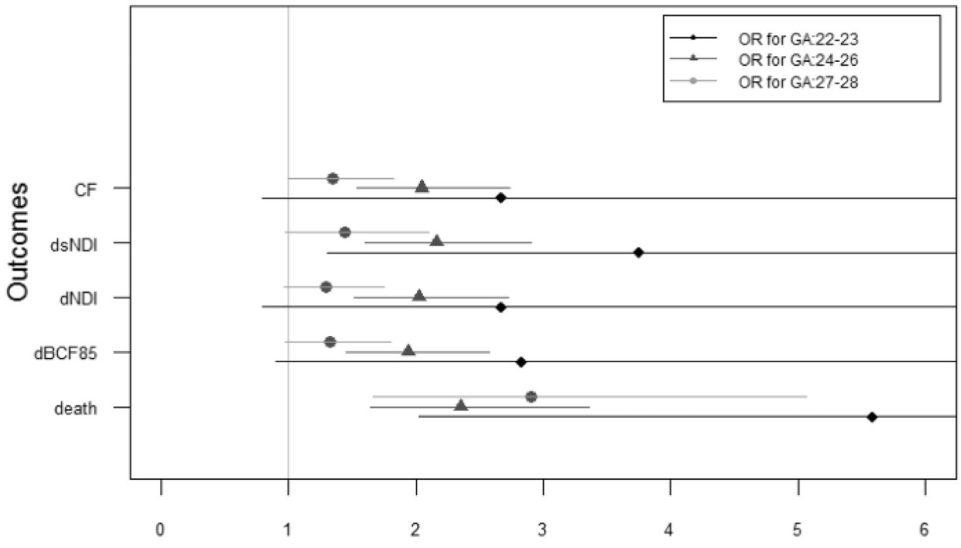


**Figure 5.** Association between outcomes and TRIPS score <20 vs TRIPS score ≥20.

**Table I. TRIPS variables, physiologic ranges, and score points**

| TRIPS variables | TRIPS score points |
|---|---|
| Temperature (°C) | |
| <36.1 or >37.6 | 8 |
| 36.1-36.5 or 37.2-37.6 | 1 |
| 36.6-37.1 | 0 |
| Respiratory status | |
| Severe (apnea, gasping, intubated) | 14 |
| Moderate (RR >60/min and/or $SpO_2$ <85%) | 5 |
| None (RR <60/min and/or $SpO_2$ >85%) | 0 |
| Systolic blood pressure (mm Hg) | |
| <20 | 26 |
| 20 – 40 | 16 |
| >40 | 0 |
| Response to noxious stimuli | |
| None, seizure, muscle relaxant | 17 |
| Lethargic response, no cry | 6 |
| Withdraws vigorously, cries | 0 |

*RR*, respiratory rate.
Adapted from Lee SK, Zupancic JA, Pendray M, Thiessen P, Schmidt B, Whyte R, et al. Transport Risk Index of Physiologic Stability: a practical system for assessing infant transport care. J Pediatr 2001;139:220-6.

**Table II. Comparison of infant characteristics between those excluded (missing TRIPS score) and the study population (TRIPS score available)**

| Characteristics | TRIPS missing (excluded) | TRIPS available = study population | *P* value |
|---|---|---|---|
| Infants, n | 1338 | 1686 | |
| Gestational age group, weeks | | | .19 |
| 22-23 | 4.26 (57/1338) | 5.52 (93/1686) | |
| 24-26 | 51.05 (683/1338) | 48.75 (822/1686) | |
| 27-28 | 44.69 (598/1338) | 45.73 (771/1686) | |
| Birth weight, grams | 909 ± 244 | 903 ± 230 | .50 |
| Outborn | 15.34 (205/1336) | 16.19 (273/1686) | .53 |
| Male sex | 57.15 (763/1335) | 53.89 (908/1685) | .07 |
| Singleton | 70.41 (940/1335) | 72.18 (1217/1686) | .28 |
| 5-minute Apgar <7 | 42.89 (567/1322) | 40.16 (669/1666) | .13 |
| Small for gestational age | 8.7 (116/1334) | 8.42 (142/1686) | .79 |
| Cesarean | 55.91 (743/1329) | 58.07 (975/1679) | .23 |
| Maternal age, years | 30.6 ± 5.9 | 30.7 ± 5.9 | .61 |
| Primipara | 53.08 (250/471) | 56.18 (927/1650) | .23 |
| Maternal hypertension | 15.12 (196/1296) | 16.55 (272/1644) | .30 |
| Maternal diabetes | 8.12 (103/1268) | 8.31 (134/1613) | .86 |
| Antenatal steroids | 87.12 (1130/1297) | 87.78 (1437/1637) | .59 |

Values are percent (n/N) or mean ± SD.
The reported *P* values were based on the comparisons between 2 groups using a $\chi^2$ test.

**Table III. Association between the characteristics and TRIPS score**

| Characteristics | Study population | TRIPS score <10 | 10-20 | 20-30 | 30-40 | ≥40 | *P* value |
|---|---|---|---|---|---|---|---|
| No. infants in study population | 1686 | 319 | 547 | 358 | 403 | 59 | |
| Gestational age group, weeks | | | | | | | <.0001 |
| 22-23 | 5.52 (93/1686) | 0.63 (2/319) | 4.2 (23/547) | 3.91 (14/358) | 10.17 (41/403) | 22.03 (13/59) | |
| 24-26 | 48.75 (822/1686) | 27.27 (87/319) | 50.27 (275/547) | 54.47 (195/358) | 56.82 (229/403) | 61.02 (36/59) | |
| 27-28 | 45.73 (771/1686) | 72.1 (230/319) | 45.52 (249/547) | 41.62 (149/358) | 33 (133/403) | 16.95 (10/59) | |
| Birth weight, grams | 903 (230) | 1039 (215) | 897 (218) | 892 (227) | 837 (218) | 756 (186) | <.0001 |
| Outborn | 16.19 (273/1686) | 8.78 (28/319) | 17.55 (96/547) | 17.88 (64/358) | 17.87 (72/403) | 22.03 (13/59) | .0022 |
| Male sex | 53.89 (908/1685) | 50.47 (161/319) | 56.67 (310/547) | 55.18 (197/357) | 51.86 (209/403) | 52.54 (31/59) | .39 |
| Singleton | 72.18 (1217/1686) | 72.1 (230/319) | 70.02 (383/547) | 70.11 (251/358) | 75.68 (305/403) | 81.36 (48/59) | .14 |
| Apgar score of <7 at 5 minutes | 40.16 (669/1666) | 11.71 (37/316) | 35.54 (193/543) | 49.72 (176/354) | 56.42 (224/397) | 69.64 (39/56) | <.0001 |
| Small for gestational age | 8.42 (142/1686) | 8.15 (26/319) | 7.68 (42/547) | 9.78 (35/358) | 8.68 (35/403) | 6.78 (4/59) | .82 |
| Cesarean | 58.07 (975/1679) | 54.55 (174/319) | 58.68 (321/547) | 61.76 (218/353) | 58.46 (235/402) | 46.55 (27/58) | .14 |
| Primipara | 56.18 (927/1650) | 53.7 (167/311) | 57.78 (312/540) | 55.07 (190/345) | 56.68 (225/397) | 57.89 (33/57) | .81 |
| Maternal hypertension | 16.55 (272/1644) | 17.72 (56/316) | 17.42 (93/534) | 15.99 (55/344) | 16.33 (64/392) | 6.9 (4/58) | .33 |
| Maternal diabetes | 8.31 (134/1613) | 10.29 (32/311) | 7.39 (39/528) | 8.93 (30/336) | 7.29 (28/384) | 9.26 (5/54) | .57 |
| Antenatal steroid use | 87.78 (1437/1637) | 94.57 (296/313) | 89.91 (481/535) | 88.05 (302/343) | 82.31 (321/390) | 66.07 (37/56) | <.0001 |

All values are percent (n/N). The reported *P* values were based on the comparisons among TRIPS score groups using a $\chi^2$ test for categorical variables and F test (ANOVA) for continuous variables.

**Table IV. Association between outcomes and TRIPS score**

| Outcomes | TRIPS score <10 | 10-20 | 20-30 | 30-40 | 40 + | *P* value* |
|---|---|---|---|---|---|---|
| All infants in the study population | | | | | | |
| n | 319 | 547 | 358 | 403 | 59 | |
| Composite outcome | 38.24 (122/319) | 46.44 (254/547) | 57.82 (207/358) | 61.29 (247/403) | 76.27 (45/59) | <.0001 |
| Mortality or significant NDI | 16.3 (52/319) | 25.96 (142/547) | 34.92 (125/358) | 42.43 (171/403) | 64.41 (38/59) | <.0001 |
| Mortality or NDI | 42.32 (135/319) | 49.36 (270/547) | 61.17 (219/358) | 62.28 (251/403) | 81.36 (48/59) | <.0001 |
| Mortality | 5.64 (18/319) | 12.8 (70/547) | 22.35 (80/358) | 30.77 (124/403) | 55.93 (33/59) | <.0001 |
| Infants survived at discharge from NICU | | | | | | |
| n | 304 | 485 | 283 | 291 | 27 | |
| Composite outcome | 35.2 (107/304) | 39.59 (192/485) | 46.64 (132/283) | 46.39 (135/291) | 48.15 (13/27) | .001 |
| Mortality or significant NDI | 12.17 (37/304) | 16.49 (80/485) | 17.67 (50/283) | 20.27 (59/291) | 22.22 (6/27) | .007 |
| Mortality or NDI | 39.47 (120/304) | 42.89 (208/485) | 50.88 (144/283) | 47.77 (139/291) | 59.26 (16/27) | .003 |
| Significant NDI | 12.17 (37/304) | 16.53 (80/484) | 17.79 (50/281) | 20.34 (59/290) | 22.22 (6/27) | .006 |
| NDI | 39.47 (120/304) | 42.98 (208/484) | 51.25 (144/281) | 47.93 (139/290) | 59.26 (16/27) | .0027 |
| Bayley III language score <85 at 18-24 months | 28.36 (78/275) | 35.85 (152/424) | 40.16 (102/254) | 34.25 (87/254) | 34.78 (8/23) | .12 |
| Bayley III cognitive score <85 at 18-24 months | 9.68 (27/279) | 13.29 (59/444) | 15.38 (40/260) | 16.92 (44/260) | 17.39 (4/23) | .01 |
| Bayley III motor score <85 at 18-24 months | 14.96 (41/274) | 18.4 (76/413) | 22.75 (58/255) | 21.74 (55/253) | 36.36 (8/22) | .005 |

All values are percent (n/N). Composite outcome: Any mortality or significant NDI or Bayley III language or cognitive or motor score <85 at 18-24 months corrected age.
**P* value is based on the Cochran-Armitage trend test.