

Validation of the Signs of Inflammation in Children that can Kill (SICK) score for assessment of illness severity

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Abstract

Background The Signs of Inflammation in Children that can Kill (SICK) score has been developed in the search for a practical triage tool in settings with limited resources for immediate, non-invasive assessment of illness severity. Its seven parameters are heart rate, respiratory rate, systolic blood pressure, temperature, blood oxygen saturation (SpO₂), capillary refill time (CRT), and level of consciousness. The SICK score also takes into account the age of the child.

Objective To assess the validity of SICK scores for differentiating between high and low probabilities of death in children.

Methods We performed a prospective evaluation of all children aged between one month to twelve years admitted to the Pediatric Emergency Care Unit at Prof. Dr. R.D. Kandou Hospital, Manado between October 2011 to January 2012. We calculated SICK scores at the time of presentation and assessed their correlation with subsequent in-hospital mortality using logistic regression analysis.

Results During the study period, we observed 230 patients, of whom 199 survived and 31 died. There were 134 males, of whom 117 survived and 17 died. The remaining 96 subjects were female, of whom 82 survived and 14 died. Logistic regression analysis revealed a significant relationship between SICK score and mortality ($P < 0.001$). With a probability of 0.5, we attained a cut off score of 4.74 points, with 96.8% sensitivity and 99.5% specificity for the prediction of mortality.

Conclusion The high SICK score is associated with higher probability of death. A cut off score of 4.74 has high sensitivity and specificity for predicting the probability of death. The SICK score may be useful as a triage tool at the patient's initial presentation, particularly in settings with limited resources.

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Keywords: SICK score, risk of mortality, severity of illness, non-invasive assessment

The Early Warning Score and Modified Early Warning Score methodologies use physiological parameters to identify high risk patients in adult general wards.^{1,2} However, they are not weighted and are based on the number of abnormal parameters. The first physiological scoring system developed for children was the *Physiologic Stability Index* (PSI), which derived a subjective score of the worst of 34 values from routinely measured variables over the first day in the pediatric intensive care unit (PICU).³ The *Pediatric Risk of Mortality Score* (PRISM) evolved as a simplified version of PSI with only 14 variables, but PRISM still uses laboratory results, making it costly and labor intensive, as well as not useful at the time of patient presentation.⁴ The problem of lead time bias was circumvented by the *Pediatric Index of Mortality* (PIM, then PIM2), which is calculated on admission to the PICU.⁵ The Signs of Inflammation in Children that can Kill (SICK) score was developed in a search for a practical triage tool for settings with limited resources. SICK, which evaluates the expected risk of mortality, utilizes the abnormal physical variables of the systemic

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inflammatory response syndrome and its continuum, the multiple organ dysfunction syndrome. Its seven parameters are heart rate, respiratory rate, systolic blood pressure, temperature, blood oxygen saturation (SpO₂), capillary refill time (CRT), and level of consciousness. It also takes age into account.^{6,7}

The development of the scoring system and the weights given to each variable, were published in a study of 1,099 consecutive children admitted into the Pediatric Department at St. Stephan's Hospital (SSH) in New Delhi, India. The authors reported regression coefficients (logs of the odds ratio of death) and their use as weightings.⁸ A subsequent study done validated the SSH study, but was limited to 125 PICU admissions. The authors also compared these SICK scores to PRISM scores.⁹ Another validation study was a two-center prospective evaluation in London and New Delhi which included 3,895 children. The earlier studies could not justify the cut off point due to the low number of deaths. Since SICK scoring evaluates the risk of mortality and is dependent on systemic signs of the inflammatory response, it is called the *Signs of Inflammation in Children that can Kill*, with the acronym SICK score.¹⁰ We aimed to assess the validity of the SICK scoring system for differentiating between high and low probabilities of death in children.

Methods

We conducted a prospective study between October 2011 to January 2012 at Prof. Dr. R.D. Kandou Hospital, Manado. This teaching hospital is associated with the Sam Ratulangi University Faculty of Medicine. We evaluated all children aged one month to twelve years who were admitted to the Pediatric Emergency Care Unit. We calculated SICK scores at the time of presentation. Axillary temperature was measured by digital electric thermometer. Capillary refill time (CRT) was evaluated on a digit after applying blanching pressure for five seconds. Level of consciousness was determined using the alert/responding to voice/responding to pain only/ or unresponsive (APVU) scoring system. Blood oxygen saturation (SpO₂) was measured with a saturation monitor applied to the skin, usually on the finger. Blood pressure was measured using a sphygmomanometer cuff covering over 75% of the upper arm length in all

cases. All parameters were recorded by physicians. The parameters used were part of routine examination of children brought to the hospital for evaluation. No special training of staff was required.

Abnormal ranges for the parameters were considered to be as follows: heart rate >160 per minute (infant), >150 per minute (child); respiratory rate >60 per minute (infant), >50 per minute (child); systolic blood pressure <65 mm Hg (infants), <75 mm Hg (child); temperature (>38°C, <36°C); SpO₂ (<90%); CRT (≥3 seconds); and level of consciousness (all states of consciousness other than alert). The variables were treated as binomial variables and classified as normal/abnormal.

The weightings taken from the previous study were: heart rate (0.2); respiratory rate (0.4); systolic blood pressure (1.2); temperature (1.2); SpO₂ (1.4); CRT (1.2); level of consciousness (2.0); and age bands <1 years (1.0), 1-5 years (0.3) and >5 years (0.0).⁹ The range of possible scores was 0 to 8.6.

We calculated SICK scores by adding the weightings of each abnormal variable using the custom-made software, *SICK Score Calculator*.¹¹ For unmeasured parameters, the software default was classified as normal. SICK score was not used to make clinical decisions. We followed all patients to the time of discharge. Outcomes were measured as survived and discharged home or death. Logistic regression was applied to the outcome using *SICK score calculator* as the predictor. Data were collected and analyzed with *SPSS software version 19*.

Results

During the study period, we observed 230 patients, of whom 199 survived and 31 died. Of the 134 males, 117 survived and 17 died. The remaining 96 subjects were female, from which 82 survived and 14 died (**Table 1**).

Table 1. Characteristics of subjects

Characteristics	Died	Survived
Age, n (%)		
<1 year	14 (45.2)	48 (24.1)
1-5 years	11 (35.5)	67 (33.7)
>5 years	6 (19.3)	84 (42.2)
Gender, n (%)		
Male	17 (54.8)	117 (58.8)
Female	14 (45.2)	82 (41.2)

Table 2 shows the difference in SICK scores between the patients who survived and died. Logistic regression analysis revealed a strong association between the score and mortality ($P < 0.0001$). Higher score values were associated with an increased probability of death, with a probability value of 0.5 and cut off point of 4.74 (**Figure 1**).

Table 2. Subjects' mean SICK scores

	Died		Survived		P value
	Mean SICK score (SD)	95% CI	Mean SICK score (SD)	95% CI	
Mean SICK score (SD)	5.97 (1.236)	5.51 to 6.47	1.55 (1.274)	1.36 to 1.72	<0.0001

Table 3 shows that the cut off score of 4.74 points had a 96.8% sensitivity and 99.5% specificity, for which the positive predictive value was 96.8% and the negative predictive value was 99.5%.

Table 3. Distribution of children based on cutoff score of 4.74 points

Cut off point score	Died	Survived	Total
>4.74	30	1	31
≤4.74	1	198	199
Total	31	199	230

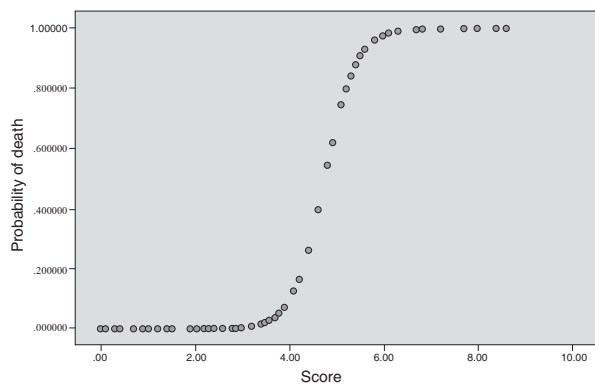


Figure 1. Relationship between SICK score and probability of death

Discussion

A physiology-based scoring system, the *Physiologic Stability Index* (PSI), has developed to assess the severity of acute illness in pediatric intensive care unit settings.³ The hypothesis of this study was that physiological instability directly reflects mortality

risk. Physiological stability was assessed by way of 34 variables from the seven systems including cardiovascular, respiratory, hematological, renal, neurologic, gastrointestinal and metabolic. *The Pediatric Risk of Mortality* (PRISM) scoring consists of systolic blood pressure, diastolic blood pressure, heart rate, respiratory rate, PaO_2/FiO_2 , $PaCO_2$, Glasgow

coma scale, pupillary reaction, prothrombin time/activated partial thromboplastin time (PT/APTT), total bilirubin, potassium, calcium, glucose, and bicarbonate measurements.⁴ The scoring system then revised down to 8 variables, including premorbidity, clinical condition, pupillary response, base excess in arterial blood, PaO_2 , FiO_2 , systolic blood pressure, and mechanical ventilation, a scoring system comparable to the *Pediatric Risk of Mortality* (PRISM) score.⁵ The mortality score requires both physical and laboratory examinations, the latter of which may be a hindrance in low-income settings. A combination of vital signs can also be used to differentiate children with serious infections in pediatric units with comparable sensitivity to a more complicated triage system.⁶ We also can use the natural history of the systemic inflammatory response syndrome (SIRS) and the evaluations of SIRS criteria as a predictor of illness severity in patients hospitalized through the emergency services.⁷

The systemic inflammatory response syndrome (SIRS) was defined by the *Consensus Conference of American College of Chest Physicians* as a host response to various infectious and non-infectious insults. Variables included are temperature, heart rate, respiratory rate, $PaCO_2$, leukocytes and IT ratio. To evolve a triage scoring system for severity of illness based on clinical variables related to SIRS, some experts proposed that two or more abnormal clinical variables might lead to death.⁸ Our study also resulted in weighting through the coefficient in multiple logistic regression analysis, which was then validated in two studies.^{10,12} They also named the score *Signs of Inflammation that Can Kill* (SICK), since this scoring

system utilized the SIRS variables to predict mortality in children. From these two studies, a cut off point was never found. We used normal values as default readings for missing values.

A limitation of our study was that scoring was done by different doctors on duty in the emergency department and we did not assess inter-rater agreement. Scoring, however, involves measurements that are quite basic in medical practice, such as the measuring of pulse rate, hence inter-rater variability was likely to be low. Another limitation was that this study did not have a blinded design. As such, pediatricians involved patient care were aware of the abnormal variables in the child they were treating and also the underlying hypothesis of the study. To mitigate this bias, the actual weights were calculated at the end of the study, after all patients' data were collected. Logistic regression analysis indicated that higher SICK scores increased the probability of death. A cut off score of 4.74 had 96.8% sensitivity and 99.5% specificity for predicting the probability of death. In conclusion, higher SICK scores indicate higher probability of death. We propose that SICK score can be a useful triage tool at initial patient presentation, particularly in settings with limited resources.

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