ARTICLE

Predictors of Death and Neurologic Impairment in Pediatric Submersion Injuries

The Pediatric Risk of Mortality Score

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Objective: To evaluate the Pediatric Risk of Mortality Score (PRISM score) as a tool to distinguish which patients presenting to the emergency department (ED) or pediatric intensive care unit (PICU) would survive neurologically intact from those who would die or survive with severe neurologic impairment following a submersion incident.

Design: Retrospective chart review.

Setting: A regional tertiary care ED and PICU.

Materials: Medical records of drowning and near-drowning patients between the ages of 1 day and 18 years who were admitted to the ED or PICU from January 1986 through December 1995.

Main Outcome Measures: For each patient, a PRISM score was calculated based on data collected at the time of arrival to the ED or PICU. A "probability of outcome" was calculated using the PRISM score. Outcomes were defined as survival with intact neurologic function, survival with severe neurologic impairment, or death, and were assessed using the Pediatric Cerebral Performance Category Scale. Scores and probabilities of outcome were compared with the actual outcome for both the ED and PICU patients using the Fisher exact test (2 tailed).

Results: All ED patients with PRISM scores less than 25 or a probability of outcome less than 50% (n=40) survived with intact neurologic function ($P<.001$). All ED patients with PRISM scores of 25 or greater or a probability of outcome of 50% or greater (n=10) either died or survived with severe neurologic impairment ($P<.001$). All PICU patients with a PRISM score of 5 or less (n=25) or a probability of outcome less than 4% (n=30) survived with intact neurologic function ($P<.05$). All PICU patients with a PRISM score greater than 20 or a probability of outcome greater than 50% either died or survived with severe neurologic impairment ($P<.05$). Outcomes could not accurately be predicted in PICU patients when the PRISM scores were 6 or greater and ≤20 or less (n=10), or when the probability of outcome was 4% or greater and 50% or less.

Conclusions: The PRISM scoring system accurately distinguished ED patients who would survive neurologically intact from those who would die or suffer neurologic impairment. There was not a specific PRISM score or probability of outcome that could distinguish PICU patients who would survive neurologically intact from those who would die or suffer severe neurologic impairment. The PRISM scoring system appeared to be more accurate in distinguishing intact survival from death or neurologic impairment in ED patients than in PICU patients.

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Editor's Note: It's interesting to find that an instrument designed for use in an intensive care unit appears to work more effectively, at least on this problem, in an emergency department. New applications work for all sorts of things.

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DROWNING, defined as death within 24 hours of a submersion incident, and near drowning, defined as survival for at least 24 hours following a submersion incident, represent significant causes of morbidity and mortality in children. Death from submersion incidents is the second-leading cause of accidental death in children,[1] with one third of all survivors sustaining significant neurologic damage due to anoxic encephalopathy.[2] Predicting neurologic outcome has emerged as a major clinical problem in near drowning.[2]

Many investigators have attempted to identify prognostic factors related to both survival and neurologic outcome from submersion incidents.[3-13] Most, however, have met with difficulties. There is still no method that accurately predicts which children will survive with intact neurologic function vs those who will either die or survive with severe brain injury. The development of a system to predict prognosis in near-drowning victims is needed. One such system may be the Pediatric risk of Mortality Score (PRISM score).[14]

The PRISM is a scoring system that predicts mortality in critically ill chil-

SUBJECTS AND METHODS

A retrospective chart review was conducted on all drowning and near-drowning patients between the ages of 1 day and 18 years who were admitted to the ED or PICU of the Robert Wood Johnson University Hospital, New Brunswick, NJ, between January 1, 1986, and December 31, 1995. Each medical record was analyzed for demographic data (age and sex) and incident characteristics (water temperature and location). Submersion incidents were classified as either "warm-water incidents" (water temperature >20°C) or "cold-water incidents" (water temperature ≤20°C) (by history noted in the chart). This distinction was based on prior literature regarding warm and cold-water incidents.[15] Exclusion criteria included preexisting neurologic conditions, head trauma or spinal cord injury at the time of the submersion incident, use of barbiturates or steroids at the time of resuscitation and/or assessment, and cold-water submersion incidents.

For each patient, a PRISM score was calculated based on data obtained at the time of arrival to the ED. A probability of outcome was then determined for each patient using the equation that computes the probability of death from the PRISM score. When PRISM scores were calculated, the scores were based on raw data obtained in the ED. The scores did not take into account any variation of prehospital resuscitation (ie, prehospital intubation, intravenous lines, or medications). These patients comprised the "ED group" of the study. The neurologic function of each patient at the time of discharge from the hospital was defined using the Pediatric Cerebral Performance Category Scale (PCPCS) of Fiser[16] (**Table 2**). Patients with a PCPCS score of 3 or less were considered to have survived neurologically intact and those with a PCPCS score of greater than 3 were considered to have severe neurologic impairment. Patients were then assigned to 1 of 2 groups according to their actual outcome. The first group consisted of patients who survived with intact neurologic function. The second group consisted of patients who survived with severe neurologic impairment as well as patients who died.

All patients from the ED group who were admitted to the PICU made up a second study group. For each of these patients, a new PRISM score was calculated based on new data obtained in the PICU. A probability of outcome was then determined for each in the same manner as with the ED patient group. When PRISM scores and the probabilities of outcome were calculated, the calculations were based on raw data obtained within 24 hours of admission to the PICU. The scores did not take into account any variation of ED resuscitation (ie, intubation, intravenous lines, or medications). These patients comprised the "PICU group" of the study. The neurologic function of each patient at the time of discharge from the hospital was defined using the PCPCS. Patients were again assigned to 1 of 2 groups based on their outcome in the same manner as were the ED patients.

The PRISM scores and probabilities of outcome were compared with the actual outcome using different cutoff points to optimize prediction of outcome for both the ED and PICU groups. Results were analyzed using the Fisher exact test (2 tailed). A *P* value of .05 or less was considered statistically significant.

Table 1. PRISM Score*

Variable	Infants (Age Restrictions and Ranges)	All Ages (Age Restrictions and Ranges)	Children (Age Restrictions and Ranges)	Score
Systolic BP, mm Hg	130-160		150-200	2
	55-65		65-75	
	>160		>200	6
	40-54		50-64	
	<40		<50	7
Diastolic BP, mm Hg		>110		6
Heart rate, beats/min	>160		>150	4
	<90		<80	
Respiratory rate, breaths/min	61-90		51-70	1
	>90		>70	5
	Apnea		Apnea	
$Pa{O_2}/F{IO_2}$		200-300		2
		<200		3
$Pa{CO_2}$		51-65		1
		>65		5
Glasgow Coma Score		<8		6
Pupillary reactions		Unequal or dilated		4
		Fixed and dilated		10
PT/PTT		1.5×control		2
Total bilirubin, µmol/L (mg/dL)		Age >1 mo >60 (>3.5)		6
Potassium, mmol/L		3.0-3.5		1
		6.5-7.5		
		<3.0		5
		>7.5		
Calcium, mmol/L (mg/dL)		1.75-2.00 (7.0-8.0)		2
		2.99-56.14 (12.0-15.0)		
		<1.75 (<7.0)		6
		<56.14 (<15.0)		
Glucose, mmol/L (mg/dL)		2.2-3.3 (40-60)		4
		13.9-22.2 (250-400)		
		<2.2 (<40)		8
		>22.2 (>400)		
Bicarbonate, mEq/L		<16		3
		>32		

Reprinted with permission from Pollack et al.[14] PRISM indicates Pediatric Risk of Mortality score; BP, blood pressure; $F{IO_2}$, fraction of inspired oxygen; and PT/PTT, prothrombin time/partial thromboplastin time.

dren.[14] The PRISM score is based on the observation that the amount and extent of physiologic dysfunction is related to the patient's mortality risk. The PRISM score has 14 physiologic variables and 23 variable ranges. For each physiologic variable, a point total is provided that directly reflects the contribution of that instability to mortality risk (**Table 1**). The total PRISM score gives a relative scale of severity of illness. A more precise estimate of mortality risk can be computed from the following equation:

$$\text{Probability of Death} = \exp(R)/[1 + \exp(R)],$$

where

$$R = 0.207[\text{PRISM score}] - 0.005[\text{age in months}] - 4.782.^{14}$$

To date, the PRISM score has not been used to predict neurologic outcome in pediatric drowning and near-drowning patients, nor has it been used for patients presenting to emergency departments (EDs). The objective of this study was to evaluate the PRISM score as a tool

Table 2. Pediatric Cerebral Performance Category Scale*

Score	Category	Description
1	Normal	Normal at age-appropriate level; school-age child attending regular school classroom
2	Mild disability	Conscious, alert, and able to interact at age-appropriate level; school-age child attending regular school classroom but grade perhaps not appropriate for age; possibility of mild neurologic deficit
3	Moderate disability	Conscious; sufficient cerebral function for age-appropriate independent activities of daily life; school-age child attending special education classroom and/or learning deficit present
4	Severe disability	Conscious; dependent on others for daily support because of impaired brain function
5	Coma or vegetative state	Any degree of coma without the presence of all brain death criteria; unawareness, even if awake in appearance, without interaction with environment; cerebral unresponsiveness and no evidence of cortex function (not aroused by verbal stimuli); possibility of some reflexive response, spontaneous eye opening, and sleep-wake cycles
6	Brain death	Apnea, areflexia, and/or electroencephalographic silence

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to distinguish which patients presenting to the ED or pediatric intensive care unit (PICU) would survive neurologically intact from those who would die or survive with severe neurologic impairment following a submersion incident. We hypothesized that the equation used to compute the "probability of death" from the PRISM score could also compute a "probability of outcome" which would distinguish those patients presenting to an ED who would die or suffer severe neurologic impairment from those who would survive neurologically intact. We further hypothesized that a probability of outcome computed from the PRISM score would likewise distinguish patients presenting to a PICU who would die or suffer severe neurologic impairment from those who would survive neurologically intact.

RESULTS

The medical records of 50 patients between the ages of 1 day and 18 years were obtained. All 50 patients were admitted directly from the submersion incident site to the ED and represented the ED group in our study. None of the patients were transported from other facilities. Of the 50 patients who presented to the ED, 3 died in the ED and 9 were discharged home or were admitted to a general pediatric ward. The remaining 38 patients were admitted to the PICU and represented the PICU group. None of the patients identified met any of the defined exclusion criteria.

The mean age of the ED patients and PICU patients was 67.3 months and 56.7 months, respectively. The median age of the ED and PICU patients was 39 months and 31.5 months, respectively. In both patient populations, the youngest age was 2 months and the oldest was 238 months. Males outnumbered females in both groups and 100% of all submersion incidents were in warm water (**Table 3**).

Table 3. Characteristics and Outcome of Patients Presenting to ED and PICU*

	ED Patients (n=50)	PICU Patients (n=38)
Mean age, mo (median)	67.3 (39)	56.7 (31.5)
Male	37 (74)	30 (79)
Female	13 (26)	8 (21)
Submersion incident		
Warm water	50 (100)	38 (100)
Pool	40 (80)	32 (83)
Private	33 (66)	26 (67)
Public	7 (14)	6 (16)
Lake	3 (6)	1 (3)
Ocean	1 (2)	1 (3)
Other	6 (12)	4 (11)
Outcome		
Intact survival	40 (80)	31 (82)
Death	5 (10)	2 (5)
Neurologic impairment	5 (10)	5 (13)

*Data are given as number (percentage), except for age. ED indicates emergency department; PICU, pediatric intensive care unit.

Pools represented the most common location for submersion incidents in both ED and PICU patients (80% and 83%, respectively). Private pools accounted for 66% and 67% of pool-related submersion incidents in ED and PICU patients, respectively (Table 3).

Of the 50 patients who presented to the ED, 40 (80%) survived with intact neurologic function, 5 (10%) died, and 5 (10%) survived with severe neurologic impairment. The cause of death in 3 of the 5 children who died was cardiopulmonary arrest, which occurred in the ED. The other 2 children who died were diagnosed as having brain death. The diagnosis of brain death was made during their ensuing hospitalization in the PICU. Of the 38 patients who presented to the PICU, 31 (82%) survived with intact neurologic function, 2 (5%) died, and 5 (13%) survived with severe neurologic impairment (Table 3). The 2 children who died were diagnosed as having brain death.

Seventy percent (35 patients) of the ED patients and 76% (29 patients) of the PICU patients experienced a respiratory arrest at the submersion incident scene. Thirty-two percent (16 patients) of the ED and 34% (13 patients) of the PICU patients experienced a cardiopulmonary arrest at the scene. Cardiopulmonary resuscitation was performed at the scene in 48% (24 patients) of the ED patients and 53% (20 patients) of the PICU patients. Endotracheal intubation was performed at the submersion scene on 18% (9 patients) of the ED patients and 16% (6 patients) of the PICU patients (**Table 4**).

All of the ED patients with a PRISM score less than 25 survived with intact neurologic function (n=40). These 40 patients had a median PRISM score of 3 and a mean of 4.8 (95% confidence interval [CI], 2.8-6.8). When the

Table 4. Prehospital Characteristics at Scene*

	ED Patients (n=50)	PICU Patients (n=38)
Respiratory arrest	35 (70)	29 (76)
Cardiopulmonary arrest	16 (32)	13 (34)
CPR	24 (48)	20 (53)
Endotracheal intubation	9 (18)	6 (16)

*Data are given as number (percentage). ED indicates emergency department; PICU, pediatric intensive care unit; and CPR, cardiopulmonary resuscitation.

PRISM score was 25 or greater, 100% of the ED patients (n=10) either died or suffered severe neurologic impairment. The 10 patients who died or survived with neurologic impairment had a median PRISM score of 37 and a mean score of 36.8 (95% CI, 32.4-41.2). Therefore, a PRISM cutoff score of 25 was found to be statistically significantly related to survival and neurologic function ($P<.001$) (**Table 5**).

When the computed probability of outcome was less than 50%, 100% of the ED patients (n=40) survived with intact neurologic function. These survivors had a median probability of 1.0% and a mean of 4.0% (95% CI, 1.2-6.9). When the computed probability of outcome was 50% or greater, 100% of the ED patients (n=10) either died or survived with severe neurologic impairment ($P<.001$) (Table 5). The 10 patients who died or survived with neurologic impairment had a median probability of outcome of 92.2 and a mean score of 87.2% (95% CI, 79.3-95.1).

The 31 patients in the PICU group who survived with intact neurologic function had a median PRISM score of 1.0 and a mean of 2.5 (95% CI, 1.1-3.9). The 7 patients in the PICU group who either died or suffered severe neurologic injury had a median PRISM score of 12 and a mean of 19.9 (95% CI, 9.4-30.3). When the PRISM score was 5 or less, 100% of the PICU patients (n=25) survived with intact neurologic function ($P<.05$). When the PRISM score was 21 or greater, 100% of the PICU patients (n=3) either died or suffered severe neurologic impairment ($P<.05$). When the PRISM scores were 6 or greater and 20 or less, we could not distinguish which PICU patients would survive with intact neurologic function from those who would either die or suffer severe neurologic impairment (Table 5).

The 31 survivors in the PICU group had a median probability of outcome of 0.7% and a mean of 1.5% (95% CI, 0.5%-2.5%). The 7 patients in the PICU population who either died or suffered severe neurologic injury had a median probability of outcome of 8.3% and a mean of 37.9% (95% CI, 1.0%-74.9%). When the probability of outcome was less than 4%, 100% of the PICU patients survived with intact neurologic function ($P<.05$). When the probability of outcome was 50% or greater, 100% of the PICU patients either died or suffered severe neurologic impairment ($P<.05$). When the probability of outcome was 4% or greater and 50% or less, we could not distinguish which patients would survive with intact neurologic function from those who would either die or suffer severe neurologic impairment (Table 5).

Table 5. PRISM Score and Probability of Outcome vs Outcome of ED and PICU Patients*

	Intact Survival	Death or Neurologic Impairment
ED Patients		
PRISM score		
≤24	40	0†
≥25	0	10†
Probability of outcome		
<50%	40	0†
≥50%	0	10†
PICU Patients		
PRISM score		
0-5	25	0‡
6-10	5	2
11-20	1	2
21-40	0	3‡
Probability of outcome		
0%-3.9%	30	0‡
4%-10%	0	4‡
11%-50%	1	0
≥51%	0	3‡

*PRISM indicates Pediatric Risk of Mortality score; ED, emergency department; and PICU, pediatric intensive care unit.
†$P<.001$.
‡$P<.05$.

COMMENT

The findings of this study bear on several relevant issues related to drowning and near drowning. These include the difficulties that previous investigators have encountered when attempting to predict survival and neurologic outcome in drowning and near-drowning patients, and the use of a physiologic scoring system to predict survival and neurologic outcome in children who have experienced submersion incidents.

Many investigators have attempted to identify prognostic factors related to both survival and neurologic outcome following submersion incidents in the hopes of identifying which patients may or may not benefit from aggressive resuscitation measures.[3-13] Their studies used submersion incident features such as submersion and resuscitation times[3,4]; cardiopulmonary function[5,6]; the Glasgow Coma Scale[7]; submersion incident–specific scoring systems[8]; various technologic modalities such as brain computed tomographic scans,[9] intracranial pressure monitoring,[10] measurements of cerebral consumption of oxygen[11] and brainstem auditory evoked potentials[12]; and laboratory studies such as serum glucose concentrations[13] to predict outcome in drowning and near-drowning patients. Based on the above factors, these studies distinguished 2 populations of patients. "Low-risk" patients survived neurologically intact and "high-risk" patients either died or suffered severe neurologic impairment. Most of these studies, however, also identified a third population, a "middle-risk" group of patients, in whom prediction of outcome was extremely difficult if not impossible.

We sought to find whether the PRISM score would accurately distinguish patients presenting to the ED or

PICU who would survive neurologically intact from those who would die or survive with severe neurologic impairment following a submersion incident. Selker[17] claimed that in order for a physiologic scoring system to accurately predict outcome and be "user friendly" for health care professionals it should have a risk-adjusted mortality predictor that is sufficiently accurate and easy to use in real-time clinical settings, provide the same mortality prediction when used prospectively as when used retrospectively, be based on the data obtained during the early course of a patient's hospital presentation, require only data that are collected in the usual care of patients, use only objective and universally collected information, be accurate at all levels of its severity scale, be compatible with other computerized clinical data systems in general use and, finally, the components of the system must be open for inspection and testing.[17]

PROPONENTS of the PRISM scoring system claim that as a predictor system the PRISM scoring system meets many of these criteria. The system is easy to use prospectively in real-time clinical settings, and as our study shows, it can be also be used retrospectively. The PRISM scoring system requires only data that are obtained in the usual care of pediatric patients and uses objective and universally collected information. Mortality is predicted based on data from the first full 24 hours after presentation to the intensive care unit (ICU). The PRISM scoring system is compatible with many computerized clinical data systems.

Among pediatric intensivists who use physiologic scoring systems, the PRISM score has gained acceptance as the most accurate predictor of morbidity and identifier of relative severity of illness in pediatric critical care medicine. To our knowledge, the PRISM score has not been used to predict neurologic outcome in drowning and near-drowning pediatric patients, nor has it been used for patients presenting to EDs.

The PRISM scoring system was highly accurate in distinguishing patients who presented to the ED who would survive with intact neurologic function from those who would either die or survive with severe neurologic impairment following a submersion injury. In predicting outcomes among patients in the PICU, the PRISM scoring system identified populations of patients who would survive neurologically intact and others who would either die or suffer severe neurologic impairment. There did not appear to be a specific probability of outcome that could distinguish those who would survive neurologically intact vs those who would die or suffer severe neurologic impairment. In this regard, the PRISM scoring system showed greater accuracy in distinguishing outcome for patients presenting to the ED than for patients presenting to the PICU following a submersion incident.

The seemingly paradoxical ability of the PRISM scoring system, an ICU scoring system, to predict outcome more accurately in ED patients than in PICU patients touches on a number of controversies regarding physiologic scoring systems. Critics of ICU scoring systems claim that the use of these systems to predict outcome is fundamentally flawed.[18] Their concern is that the physiologic data that are collected and then used in the scoring process have been influenced by medical and nursing interventions. The effects of these interventions on the physiologic data (ie, the influence of pressors on blood pressure) are not accounted for by the scoring systems. Interventions then skew the data collected and affect the score that is based on those data. This in turn invalidates the scoring system and the predicted outcome.[18] In studies evaluating the ability of the Acute Physiology and Chronic Health Evaluation (APACHE) scoring system, ICU interventions were believed to invalidate the physiologic scores and affect the ability of the APACHE scoring system to predict outcome in medical and surgical adult ICU patients.[19-22] Selker[17] claimed that for this reason, the ideal physiologic scoring system should base its predictions on data from the first minutes of hospital presentation before interventions affect physiologic data.

Others argue, however, that prior therapy does not significantly influence physiologic scores if data are obtained within the first 24 hours of hospitalization.[23] Knaus et al[24] found no statistically significant differences in APACHE scores when data were obtained either in the first few minutes or within 24 hours of hospitalization in adult ICU patients. In a large multicenter study, Pollack et al[25] found that measurement frequency of physiologic variables did not significantly affect the performance of mortality prediction with the PRISM score.

In the present study, most of the data obtained from ED patients were collected within the first few minutes of hospitalization, prior to medical intervention (eg, endotracheal intubation, mechanical ventilation, pressor support). Data from the PICU patients, however, were often obtained after many of these medical interventions had occurred. These medical interventions may have skewed the PRISM scores obtained from data collected in the PICU patients whereas PRISM scores obtained from ED data were unaffected. This may account for the PRISM scoring system's greater accuracy in distinguishing outcome in patients presenting to the ED than in patients presenting to the PICU following a submersion incident. In this regard, Bratton et al[26] found that the timing of data collection was critical when attempting to predict outcome in submersion injury patients. These investigators found that a 14-point coma scale that evaluated cortical and brainstem function was extremely reliable at predicting outcome when performed 24 hours after the submersion incident.

Another possible explanation for the discrepancy in the PRISM scoring system's ability to accurately predict outcome in ED patients vs PICU patients is what many believe to be a common limitation among ICU scoring systems. Civetta[27] suggested that there are 3 general populations of ICU patients: low risk, medium risk, and high risk. He argued that ICU scoring systems perform well at predicting outcomes in the low- and high-risk populations. Outcomes are not as accurately predicted in the middle-risk population by scoring systems because many of the physiologic variables used in the scoring process are not profoundly abnormal.[27] In the present study, 3 populations of PICU patients were in fact identified. Patients with PRISM scores less than 6, or probabilities of outcome less than 3.9% may be considered a low-risk population whose outcomes (survival with intact neurologic function) were accurately predicted by the PRISM scoring system. Patients with PRISM scores greater than 20, or probabilities of outcome greater than 50% may be considered a high-risk population whose outcomes (death or survival with neurologic impairment) were likewise accurately predicted by the PRISM scoring system. Patients with PRISM scores of 6 or greater and 20 or less, or probabilities of outcome of 4 or greater and 50% or less may be considered a medium-risk population. The PRISM scoring system could not accurately predict outcome in this group of patients. Interestingly, there did not appear to be a medium-risk population of ED patients. It is possible that medical interventions in ICUs not only invalidate outcome predictions by affecting physiologic data from which predictions are made, but these interventions also may themselves create a medium-risk population of patients in which accurate outcome prediction becomes extremely difficult if not impossible.

The present study also relates to another controversial issue, which is whether a physiologic scoring system such as the PRISM scoring system, intended for use in predicting mortality in a general population of ICU patients, can be used effectively to predict outcomes in patients with specific conditions and disease processes. The study by van Veen et al[28] found that the PRISM scoring system was not accurate in predicting mortality in oncologic patients in a pediatric ICU. Zobel et al,[29] however, noted that the PRISM scoring system accurately identified patients at increased risk for mortality after cardiac surgery. Madagame et al[30] found that the best predictor of death for children requiring mechanical ventilation during therapy for acute bacterial meningitis was the admission PRISM score. Our findings in the ED patients suggest that the PRISM scoring system can accurately predict outcome for a specific condition (submersion incidents). Findings from the group of PICU patients in our study do not, however, support such a conclusion.

To our knowledge, the PRISM scoring system has never been used to predict neurologic outcome in pediatric drowning and near-drowning patients. Many have questioned the ability of ICU scoring systems to predict outcomes other than mortality.[31] Ruttimann et al[32] found the PRISM scoring system to be accurate in predicting pediatric ICU patient outcome status as independently functional, compromised functional or dead when used in conjunction with the Pediatric Overall Performance Category score. Madagame et al[30] found the PRISM score to be the best predictor of functional outcome of children requiring mechanical ventilation during therapy for acute bacterial meningitis. The PRISM scoring system, in the present study, did not predict neurologic prognosis as an isolated outcome measure. When neurologic outcome was combined with mortality or survival, however, the PRISM scoring system accurately predicted outcome in 100% of ED patients and certain PICU patients.

This study is potentially limited by its retrospective design. Of specific concern is whether the accuracy noted by the PRISM scoring system in this retrospective study can be reproduced in a prospective investigation. Selker et al[33] developed a physiologic scoring system, the Time-Insensitive Predictive Instrument (TIPI), to assess the likelihood of adult patients having acute cardiac ischemia and thus the appropriateness of admission to a coronary care unit. The TIPI proved to be valid both for real-time clinical use and for retrospective review.[33] Whether the PRISM scoring system is "time insensitive" in predicting outcome in patients who experience a submersion incident needs to be determined.

Our study's small sample size may have affected our findings. A larger sample size may have included ED patients in whom the PRISM scoring system would not have been able to accurately distinguish intact survival from death or survival with severe neurologic impairment. It would be worthwhile to perform a large multicenter prospective study to evaluate the accuracy of the PRISM scoring system in predicting outcome in patients presenting to EDs and PICUs following submersion incidents.

Another potential limitation of this study concerns the problems of collecting PRISM data in the ED. Some of the data used to compute PRISM scores are based on laboratory tests that are more often performed in PICUs rather than in EDs. Emergency department patients who were never admitted to the PICU most likely did not have many of these PRISM data measured. This may in turn bias the calculation and interpretation of the PRISM scores of these patients. In a study that investigated the influence of missing values on physiologic scoring systems, Knaus et al[24] claimed that if a physiologic measurement is not available, it is overwhelmingly likely that it is normal and would not affect the physiologic score.

To our knowledge, the PRISM scoring system has never been used to predict outcome in pediatric patients in the ED. The present study raises the question of whether there are potential dangers in using a tool that was designed for a PICU setting in a totally different setting. As previously stated, controversies exist as to whether differences in data collection, measurement frequency of physiologic variables, and patient interventions between different ICUs significantly influence physiologic scores. These differences may become strikingly influential if the PRISM scoring system is used in a setting other than a PICU. Large multicenter studies evaluating the accuracy of the PRISM scoring system in EDs may address these controversies and prove worthwhile.

The findings of this study and any investigation that uses ICU scoring systems to predict morbidity and mortality must be treated with caution when assessing outcomes and making decisions regarding individual patients in a "real-time" clinical setting. Prognostic systems will never predict outcome with 100% specificity; high severity scores, therefore, will never indicate absolute irreversibility of disease or impossibility of survival.[23] Christensen et al[34] claimed that individual outcome cannot be reliably predicted in the ED; therefore, aggressive resuscitation of near-drowning victims should be performed. As knowledge of pediatric cardiopulmonary resuscitation improves, more children survive submersion incidents; however, the number of severely neurologically impaired submersion victims is increasing.[3] The PRISM scoring system may provide useful objective data to physicians who must make difficult decisions regarding patient triage and escalation or withdrawal of therapy in critically ill drowning and near-drowning patients. The

PRISM scoring system may also prove helpful in efforts to inform families of a patient's probable outcome after a submersion incident. Decisions regarding the escalation or withdrawal of therapy in critically ill submersion injury patients cannot solely be based on the PRISM score or any other physiologic scoring system. Rather, these decisions must be based on a wide array of physiologic, clinical, psychosocial and emotional information that are relevant to each individual patient.

In conclusion, in the present study, the PRISM scoring system accurately distinguished ED patients who survived neurologically intact from those who died or suffered neurologic impairment. Although the PRISM scoring system identified certain populations of PICU patients who would survive neurologically intact and others who would either die or suffer severe neurologic impairment, there did not appear to be a specific probability of outcome or PRISM score that could predict outcome in PICU patients. Paradoxically, the PRISM score appeared to be more accurate in predicting outcome in ED patients than in PICU patients in this retrospective study of drowning and near drowning. A large multicenter prospective study evaluating the accuracy of the PRISM scoring system in predicting outcome in patients after a submersion is warranted.

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