
بسم الله الرحمن الرحيم
ENG
6:58 PM
12/7/2018

Mashhad University of Medical Sciences

In the name of God

Health Information Technology Department
Mashhad University of Medical Sciences

Pediatric Index of Cardiac Surgical Intensive Care Mortality Risk Score for Pediatric Cardiac Critical Care

Lecturer Name: Fatemeh Rahmatinezhad

Supervisor Name: Dr Kimiafar

Email Address: Rahminezhadf961@mums.ac.ir

Pediatric Index of Cardiac Surgical Intensive Care Mortality Risk Score for Pediatric Cardiac Critical Care

Content

Lecturer Name: Rahmatinezhad fatemeh

INTRODUCTION

Comparing healthcare outcomes among populations is an important element in the evaluation of healthcare quality and benchmarking. Increasingly, providers, consumers, administrators, policy makers, and payers are demanding evidence that healthcare services are delivered effectively and efficiently and in accordance with current standards of practice.

INTRODUCTION

Importantly, the comparison of outcomes among centers requires adjusting for some measure of patients' or population's severity of illness, such as the

- Risk of mortality →to avoid inaccurate conclusions regarding quality of care and center performance.
- In addition, studying populations for comparative effectiveness research or to improve quality by comparing therapeutic approaches requires the assurance that the **populations being studied are comparable** with regard to severity of illness.
- Reliable comparative analysis of outcomes depends on a clear understanding of the factors that influence the risk of mortality for populations of critically ill children so that proper risk adjustment may occur

INTRODUCTION

- In pediatric critical care, several physiologic-based scoring systems have been developed for risk adjustment within clinical datasets and among ICUs .
- These tools enable the establishment of baseline severity-of-illness measurement that provides an estimated mortality for the critically ill population being evaluated.
- The predicted mortality may then be compared with the actual mortality to calculate a standardized mortality ratio (SMR) to account for the variation in severity of illness (5).

INTRODUCTION

- There is evidence that the performance **of generic risk-adjustment tools** suffers when specific patient populations (cardiac, postoperative, leukemia, etc.) are not similar to the heterogeneous population in which they were developed
- As such, pioneers in the field of risk adjustment suggest that diagnosis-specific scores may be advantageous when **comparing** the outcomes of multiple ICUs (5–9).

INTRODUCTION

- Risk adjustment for pediatric populations undergoing cardiac surgery proses unique challenges.
- In addition to the wide variability in surgical case complexity, variations in anatomy
- may dramatically alter the degree of difficulty for a given surgical procedure.
- Comorbidities, which are frequently encountered
- in patients with congenital heart disease, may often **increase the risk of mortality**,independent of the surgical procedure being performed.
- Existing cardiac severity-of-illness scores, such as Risk Adjustment for Congenital Heart Surgery (RACHS), Society of Thoracic Surgeons-European Association of Cardio-Thoracic Surgery Congenital Heart Surgery Mortality (STAT) scores, and Aristotle scores, assess overall cardiac surgical mortality across the entire care process but do not assess severity of illness **at admission to the ICU.**

MATERIALS AND METHODS

- Data entered into Virtual PICU System (VPS) database by trained data collectors using standardized data definitions and routinely assessed for interrater reliability, which was greater than 93% concordance
- After data submission, all data were reviewed and validated prior to inclusion in the dataset used for quality measures and for research studies.
- This study focused on children with congenital heart defects who had cardiac surgery &discharged from either a PICU which contributed data to the VPS database from July 1, 2009, to June 30, 2012.
- Only data from ICUs that managed postoperative pediatric cardiac surgical patients and collected data for both (PIM)&(PRISM were included to assure the availability of multiple physiologic and diagnostic variables to assess for inclusion in a cardiac score.

METHODS

- Cardiac surgical patients having surgery either before or after admission to the ICU were selected. Patients unable to have a STAT score derived from the index procedure were excluded.
- Admission time with respect to cardiac surgery (ATrS) was analyzed due to the hypothesis that physiologic variables are different for patients admitted to a cardiac ICU directly from the operating room as compared **with** those admitted preoperatively.
- postoperative physiologic data were included in the PICSIM model.

METHODS -VARIABLES

- Physiologic variables that were collected within the **first hour** and **12 hours** of ICU admission and were used to calculate PIM-2 and PRISM-3
- There were 30 physiologic and patient characteristics variables considered originally. In addition, 2 diagnosis-based criteria (also used in PIM-2) were selected based on their clinical relevance for cardiac surgical patients.
- This amounted to an initial set of 32 independent variables. Some of the continuous variables were discretized depending on specific thresholds to 1 if YES and 0 if NO, for example, patients having creatinine > **0.6** mg/dL = 1; 0 if up to 0.6 mg/dL.

STATISTICAL METHODS

- Multivariate logistic regression with stepwise selection was used to develop a model to predict mortality in the ICU for cardiac surgical patients.
- 13 variables, described in Table 1, were finally selected for determination of the risk of mortality algorithm. The regression coefficients for the selected variables were determined.
- Predicted mortality was modeled in the standard fashion:

- رگرسیون لجستیک چند متغیره با انتخاب گام به گام برای ایجاد مدل پیش بینی مرگ و میر در ICU برای بیماران جراحی قلبی مورد استفاده قرار گرفت.

TAbLE 1. Variables Included in the Pediatric Index of Cardiac Surgical Intensive Care Mortality

Variable	Value	Type
Extracorporeal membrane oxygenation within 12 hr of surgery	1 if yes; 0 if no	Categorical
STAT score	0.1–5	Continuous
Hypoplastic left heart syndrome present	1 if yes; 0 if no	Categorical
Mechanical ventilation during the first hour in ICU	1 if yes; 0 if no	Categorical
$FIO_2 > 0.80$	1 if yes; 0 if no	Categorical
Creatinine > 0.60 mg/dL	1 if yes; 0 if no	Categorical
Abnormal hemoglobin < 6 g/dL or > 15 g/dL	1 if yes; 0 if no	Categorical
CO_2 partial pressure greater than 55 mm Hg (from arterial blood gas)	1 if yes; 0 if no	Categorical
Abnormal sodium Na < 137 mmo/L or > 147 mmol/L	1 if yes; 0 if no	Categorical
Patient's average respiratory rate (breaths/min) (range)	7–118	Continuous
Average systolic blood pressure (mm Hg) (range)	31–173	Continuous
STAT score squared	0–25	Continuous
Admission time with respect to cardiac surgery	1 if preoperative; 0 everything else	Categorical

STAT = Society of Thoracic Surgeons-European Association of Cardio-Thoracic Surgery Congenital Heart Surgery Mortality.

$$\text{Probability of Death} = \frac{1}{1+\exp(-L)},$$

where the logit (L) is a linear combination of risk factors with the following form:

$$L = b_0 + \sum_{j=1}^{M} b_j \times r_j.$$

The first term on the right side of last equation is an intercept
the second is a sum of the contributions from each of the risk factors *rj*, weighted by a coefficient *bj*,
→which quantifies how much each risk factor contributed to the outcome among the final 13 risk variables.

METHODS

The initial cohort was randomly separated into development and validation sets. 75% of the initial 16,574 patients were used to determine the coeffcients of the risk variables in the logit for mortality, *L*, by maximization of the likelihood function. (AUC) was compared with STAT score, STAT categories, and RACHS scores.

The remaining 25% of the cohort was then used to validate the model by analyzing the receiver operating curve (ROC) and the AUC (14). (Train →Test)

Calibration of the PICSIM model was tested by the Hosmer-Lemeshow goodness-of-fit test

The statistical analysis was done with the R

RESULTS

From a total of 123,359 ICU patients discharged from July 2009 to June 2012 in the VPS dataset, there were 16,574 cardiac surgical patients from **55 PICUs**.

The median number of patients included from each PICU was 188 ranging from (19 to 1,374).

55% of the patients were male

60% were Caucasian(Indo-European)

most of the patients (80%) were admitted to the ICU directly

The median age was 7.8 months (range of 0.01 and 673.31)

2.9% of patients were over 18 years.

Of the 16,574 patients, 428 patients (2.6%) **died**in the ICU.

RESULTS

Severity of Illness Score	Standardized Mortality Ratio	Area Under the Curve
Pediatric Index of Cardiac Surgical Intensive Care Mortality	0.92	0.87
Pediatric Index of Mortality-2	0.54	0.81
Pediatric Risk of Mortality-3	0.84	0.82
STAT score	—	0.77
STAT category	—	0.75

Table 2 demonstrates that calibration **was acceptable over all age ranges.**
The results for the validation set (n = 4,143) are summarized in Table 2 .The SMR values suggest that PICSIM (0.92)predicted deaths for the cardiac surgical population better thanPIM-2 (0.54) or PRISM-3 (0.84).

RESULTS

In addition, the performance of the PICSIM model in both ATrS (**Table 4**) (ROC values of 0.87 and 0.75 for the postoperative and preoperative admissions, respectively

Admission Time With Respect to Cardiac Surgery	*n*	Area Under the Curve	Hosmer-Lemeshow, *p*
PICSIM preoperative	746	0.75	0.49
PICSIM postoperative	3,397	0.87	0.22

PICSIM = Pediatric Index of Cardiac Surgical Intensive Care Mortality.

RESULTS

Performance of the PICSIM score with that of STAT and RACHS scores were compared

- The discrimination based on the AUC for PICSIM score (0.87) >
- The STAT score (0.77)
- The STAT categories (0.75
- The RACHS Scores (0.74).

- However, the RACHS analysis was performed with a slightly smaller number of cases (457 less), as over 11% of the cases for which PICSIM scores were able to be determined were unable to be assigned a RACHS-1 score.

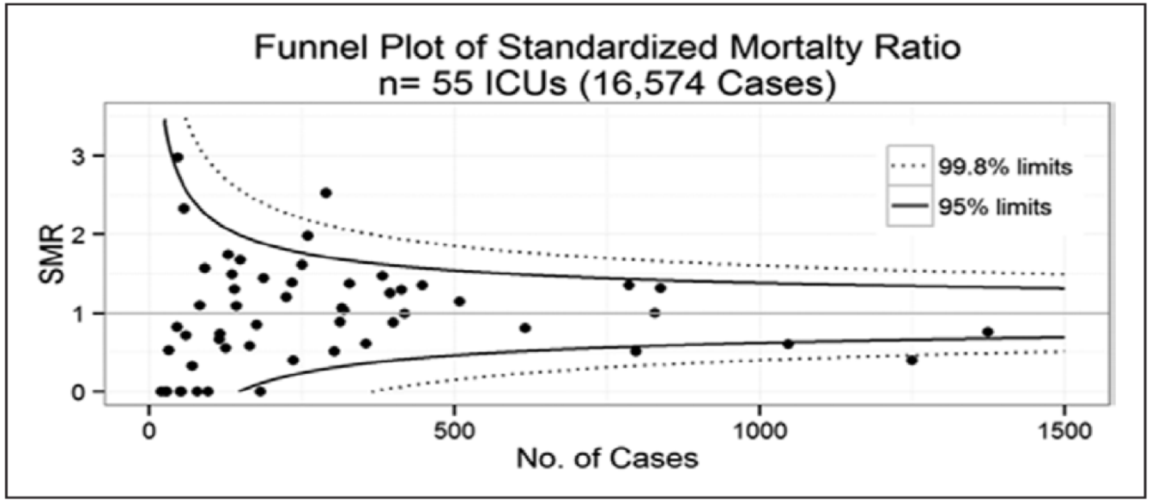
RESULTS

SMRs of participating institutions ranged from **0** (no deaths) to **3** (3 times more deaths observed than predicted)

A useful way of comparing SMRs among institutions is the funnel plot (**Fig. 3**).

This graphical representation of SMR versus volume per unit

- ❑ useful format for understanding the volume outcome relations .
- ❑ assessing performance outliers while controlling for volume among institutions .



$$SMR = \frac{Observe}{Predicte}$$

Best when 1 for model

DISCUSSION

- Several models have been developed to predict pediatric cardiac surgical mortality based on operative complexity or anatomy, such as
- RACHS-1 score (17),
- Aristotle Complexity Score (19),
- STAT score (10, 11).
- Nonetheless, none of these scores assess the physiologic condition and severity of illness at the time of admission to the ICU.

DISCUSSION

- PICSIM is the first attempt to combine physiologic, anatomic, and procedural variables available at the time of ICU admission to predict ICU mortality.
- The PICSIM variables include
- indicators of cardiac anatomy and risk → (STAT score, hypoplastic left heart syndrome), cardiorespiratory function (respiratory rate*** blood pressure***Fio2***mechanical ventilation)*** renal function (creatinine)***laboratory tests (sodium and hemoglobin).
- Thus, PICSIM includes variables relevant to multiple systems as well as cardiac surgical risk. In addition, the ATrS variable allowed the timing of surgery to be considered.

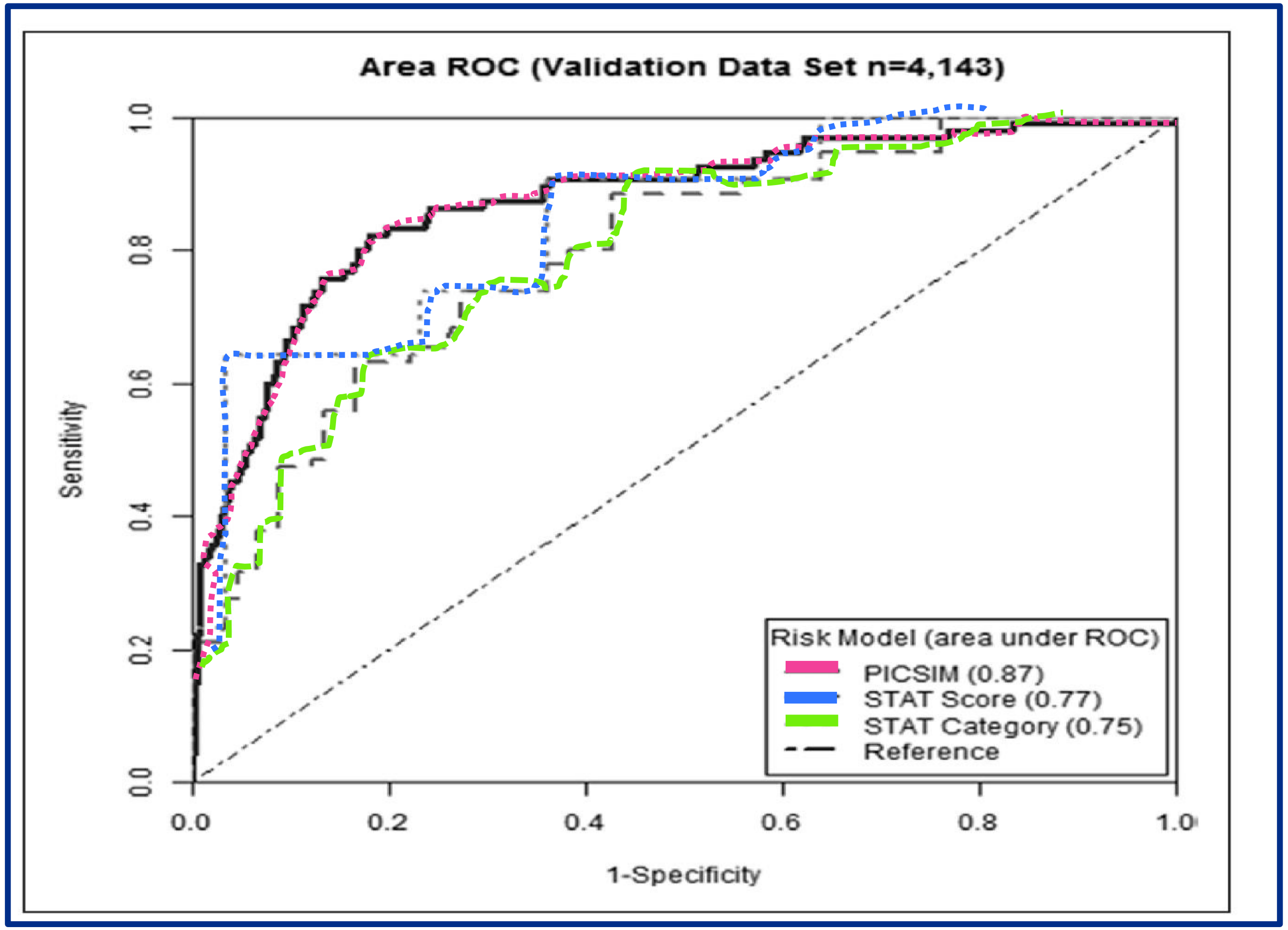
DISCUSSION

- As evidenced by improved SMRs and the AUC of the ROC, PICSIM demonstrated improved utility and better discrimination compared with PIM-2 and PRISM-3.

This improved performance may be due to the inclusion of variables not included in either PRISM-3 or PIM-2, notably the STAT score and ATrS.

- A further reason for improved performance may be that it was calibrated specifically in a cardiac surgical population.

PICSIM have improved discrimination compared with the STAT score, STAT categories.
PICSIM score is more suitable for predicting ICU mortality & assessing ICU performance for cardiac patients



DISCUSION

Another advantage of PICSIM is that it has been developed in a large diverse population from 55 ICUs representing 28 states, including patients from

- small to large ICUs with or without fellowship programs
- general and pediatric free-standing hospitals
- demographically and age diverse

thus ensuring wide applicability in the cardiac surgical population.

LIMITATIONS

- First, PICSIM needs to be validated over time for continued reproducibility and could be subject to the same "drift" reported in other prediction models.
- Second, only variables available in the VPS dataset were used—potentially prospective collection of other variable could improve performance of PICSIM.
- Third, the model was validated in a cohort of U.S. hospitals and should be validated internationally.
- Fourth, only those VPS centers that collected PRISM-3 variables were included in the study, which limited the number of eligible sites and may have introduced selection bias.
- Fifth, although the data used to develop this model were obtained from a high-quality clinical dataset, the potential for misclassifcation bias remains.
- Sixth, discrimination and calibration for PICSIM in the preoperative population were rather modest compared with the postoperative population (AUCs, 0.75 and 0.87, respectively) (Table 4).

LIMITATIONS

- These two populations are fundamentally different;

the preoperative admission cohort, in addition to not having had surgery, tends to be neonates with greater mortality (5%),

whereas the postoperative cohort is older with lower mortality (1.5%).

Although inclusion of the ATrS term improved PICSIM performance and permitted one score overall,

we advise repeating the PICSIM score following surgery to more accurately reflect the risk of mortality postoperatively.

SUGGESTION

Newer statistical approaches, such as

machine learning ,to discover relationships between multiple variables and outcomes

Future application of these newer promising “big data”approaches may provide better understanding of severity-of-illness scoring in pediatric critical care

CONCLUSION

- severity-of-illness scores, like PICSIM, are necessary for exploring efficiency and efficacy of ICU care (26, 27). The SMR is a cornerstone in benchmarking ICU quality and requires a prediction of mortality score (28).
- Benchmarking allows comparison among ICUs and internal tracking of improvements in care over time in a given ICU **to establish standards for measuring** performance & quality, which cannot be improved without appropriate assessment.

CONCLUSION

- scoring and risk prediction systems will increasingly → the judges of our clinical activities.
- severity-of-illness adjustment is necessary
- to compare study cohorts
- to assure similar mortality in study groups for comparative effectiveness

CONCLUSION

- Pollack and Getson (30) have demonstrated that daily tracking of individual SOI scores can reduce costs and improve efficiency in PICUs.
- The congenital cardiac care process begins at birth with diagnosis and continues with cardiology care, surgical evaluation, and correction with cardiopulmonary bypass through intensive care and into postsurgical follow-up.
- All steps of this process must be evaluated to guide improvement of the quality of the care provided for these children.
- تمام مراحل این فرآیند باید ارزیابی شود تا کیفیت مراقبت های ارائه شده برای این کودکان بهبود یابد

با تشکر از توجه شما

Health Information Technology Department
Mashhad University of Medical Sciences

- نام ارائه دهنده:فاطمه رحمتی نژاد
- ایمیل ارائه دهنده:Rahmatinezhadf961@mums.ac.ir