

ASSESSMENT AND OPTIMIZATION OF PROGNOSTIC SCORES IN PORTUGUESE PICUs

Introdução à Medicina II

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ASSESSMENT AND OPTIMIZATION OF PROGNOSTIC SCORES IN PORTUGUESE PICUs

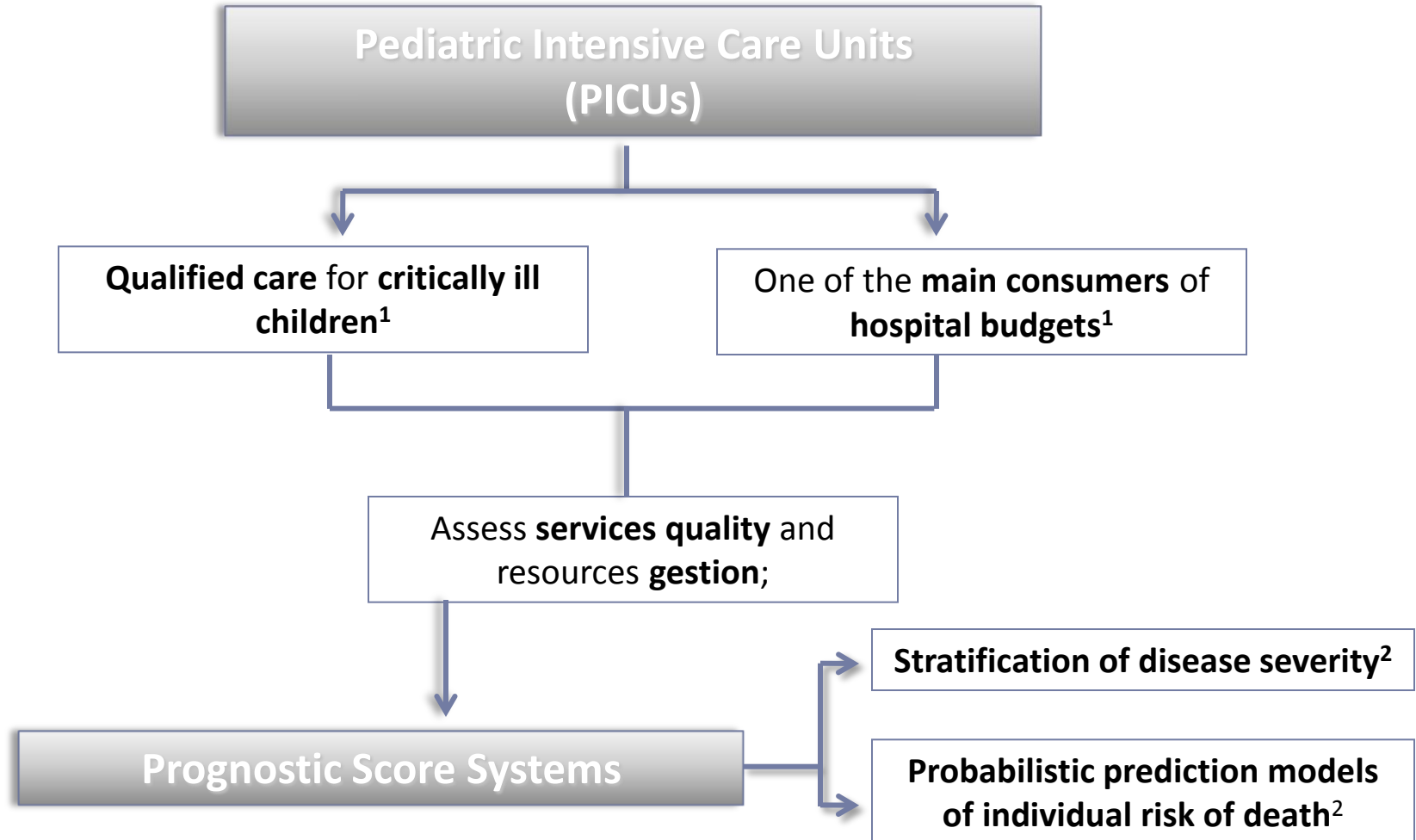


“Are they doing a good job?”

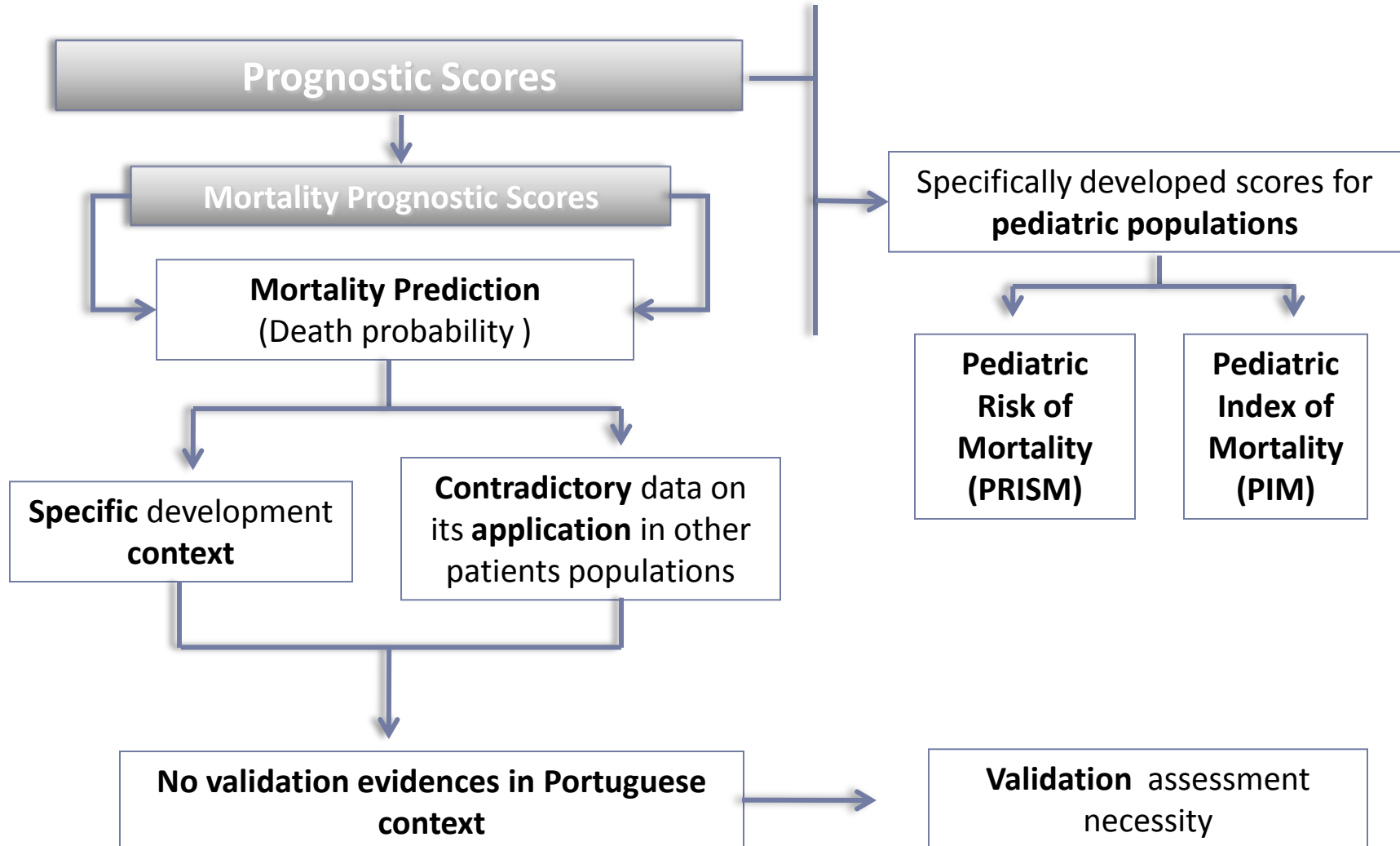
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- ▶ **PIM2: A better fit to Portuguese reality?**

INTRODUCTION



INTRODUCTION



STATE OF THE ART

Assessment and Optimization of Mortality Prediction Tools for Admissions to Pediatric Intensive Care in the United Kingdom

ABSTRACT

RESULTS. Of 26 PICUs in the United Kingdom, 22 (85%) were recruited, and sufficient prospective data were collected from 18 (69%) units on 10 197 (98%) of 10 385 admissions between March 2001 and February 2002. All published tools were found to have poor calibration but provided good discriminatory power. After estimation of UK-specific coefficients, only PIM2, PRISM III-12, and PRISM III-24 had satisfactory calibration. All models provided good discriminatory power. Funnel plots for all of the recalibrated models indicated that the risk-adjusted mortality for all units was consistent with random variation.

CONCLUSIONS. PIM2, PRISM III-12, and PRISM III-24 all were found to be suitable for use in a UK PICU setting. All tools provided similar conclusions in assessing the distribution of risk-adjusted mortality in UK PICUs. It now is important that these tools be used to monitor outcome and improve the quality of pediatric intensive care within the United Kingdom.

Pediatric Index of Mortality 2 score in Italy: a multicenter, prospective, observational study

Abstract *Objectives:* To assess the performance of the Pediatric Index of Mortality (PIM) 2 score in Italian pediatric intensive care units (PICUs). *Design:* Prospective, observational, multicenter, 1-year study. *Setting:* Eighteen medical–surgical PICUs. *Patients:* Consecutive patients (3266) aged 0–16 years admitted between 1 March 2004 and 28 February 2005. *Interventions:* None. *Measurements and main results:* To assess the performance of the PIM2 score, discrimination and calibration measures were applied to all children admitted to the 18 PICUs, in the entire population and in different groups divided for deciles of risk, age and admission diagnosis. There was good discrimination, with an area under

the receiver operating characteristic (ROC) curve of 0.89 (95% CI 0.86–0.91) and good calibration of the scoring system [non-significant differences between observed and predicted deaths when the population was stratified according to deciles of risk (χ^2 9.86; 8 df, $p = 0.26$) for the whole population]. *Conclusions:* The PIM2 score performed well in this sample of the Italian pediatric intensive care population. It may need to be reassessed in the injury and postoperative groups in larger studies.

Keywords Pediatric intensive care unit · Severity score · Mortality · Pediatric index of Mortality · Children

GENERAL AIMS

- ▶ **Assessment to Pediatric Risk of Mortality (PRISM, PRISM III) and Pediatric Index of Mortality (PIM and PIM2) systems for use in comparing the risk-adjusted mortality of children after admission for pediatric intensive care in Portugal;**
- ▶ Validation of PRISM, PRISM III, PIM and PIM-2 prognostic scores.
 - ▶ Comparing their **performance** at a general Portuguese Pediatric Intensive Care Units;
- ▶ Statistical evaluation of PRISM, PRISM III, PIM and PIM-2 scoring systems' discrimination, calibration and predictive degree at Portuguese PICU's.

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- ▶ **Statistical evaluation** of PRISM, PRISM III, PIM and PIM-2 scoring systems' **discrimination, calibration and predictive degree** at Portuguese PICUs;

Validation

- An integrated evaluative judgment of the degree to which **empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences** and actions based on test scores or other modes of assessment.⁴

Case mix

- **The type or mix of patients** treated by a hospital or unit; the key funding model currently used in Australian health care services for reimbursement of the cost of patient care.

STUDY DESIGN

I) Data acquisition

II) Algorithms calculation

III) Statistical validity assessment

→ Via PASW 18.0 and other Microsoft Office resources

Standard Criteria

- Discrimination
- Calibration
- Explanatory power

Bases of defined strategy

- ▶ Precursor project – **REUNIR** (*Recolha Uniformizada e Nacional de Informação Relevante*);
- ▶ Conducted Study in UK (same thematic and analytical bases);⁵
- ▶ Other Prognostic Scores Validation Studies in Portugal [e.g. **APPACHE** (*Acute Physiology, Age, Chronic Health Evaluation*), **SABS** (*Clinical Risk Index for Babies*)];⁶

I) Previously created database

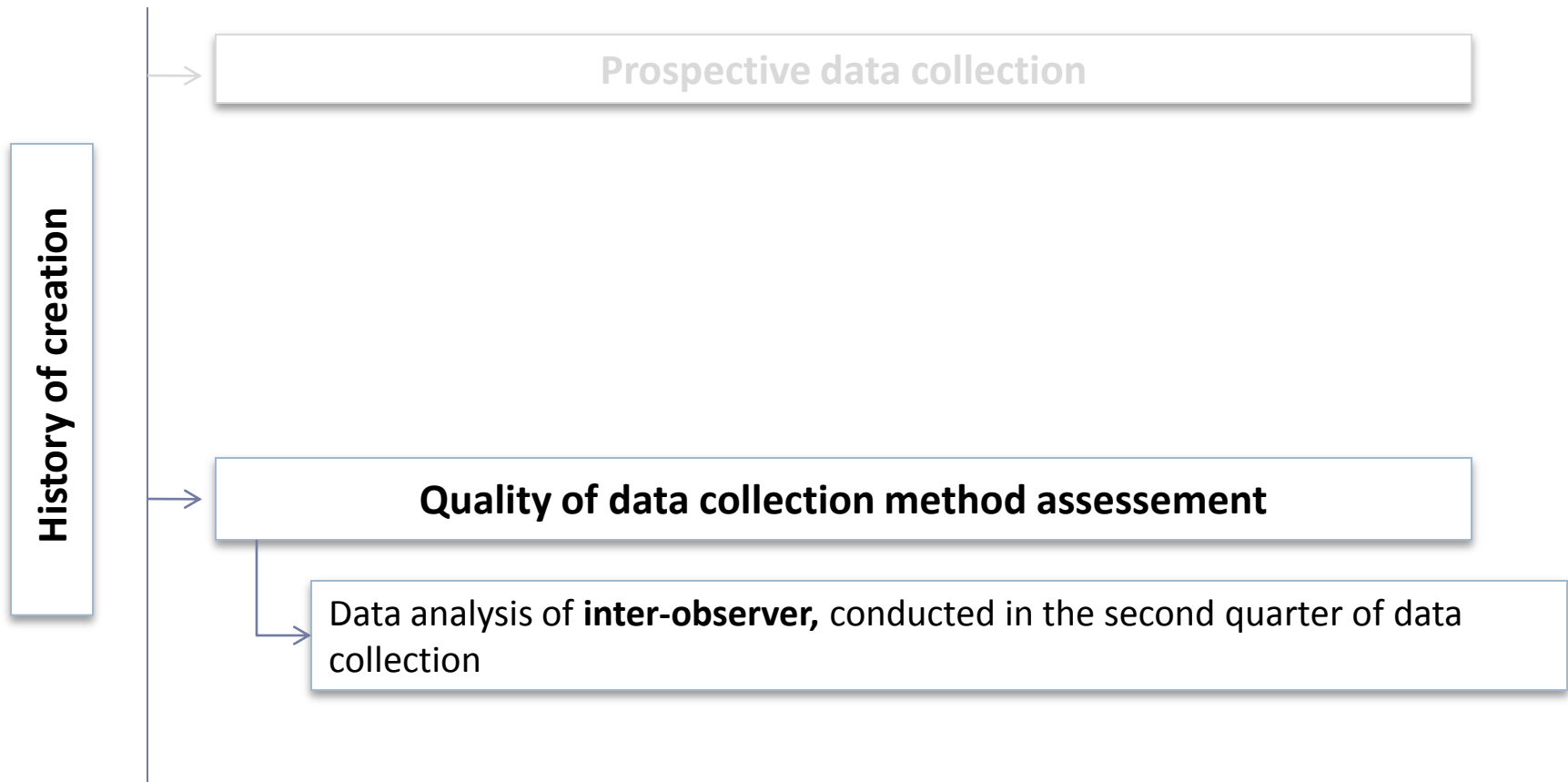
History of creation

Prospective data collection

- **Time of collection:** 30 months
- **Institutions of collection:** 3 volunteers Portuguese PICU's (Hospital Pediátrico de Coimbra - Coimbra, Hospital D. Estefânia - Lisbon, Hospital São João - Oporto)
- **Dimension:** 2000 patients
- **Inclusion / Exclusion criteria:** All admissions between 29 days and 16 years old; No more criteria are known;
- **Data:** All necessary data for PIM, PIM II, PRISM, PRISM III calculation (Routinely collection; Added pro-form);

DATA AQUISITION

I) Previously created database



STUDY DESIGN

I) Data acquisition

II) Algorithms calculation

III) Statistical validity assessment

→ Via PASW 18.0 and other Microsoft Office resources

Standard Criteria

- Discrimination
- Calibration
- Explanatory power

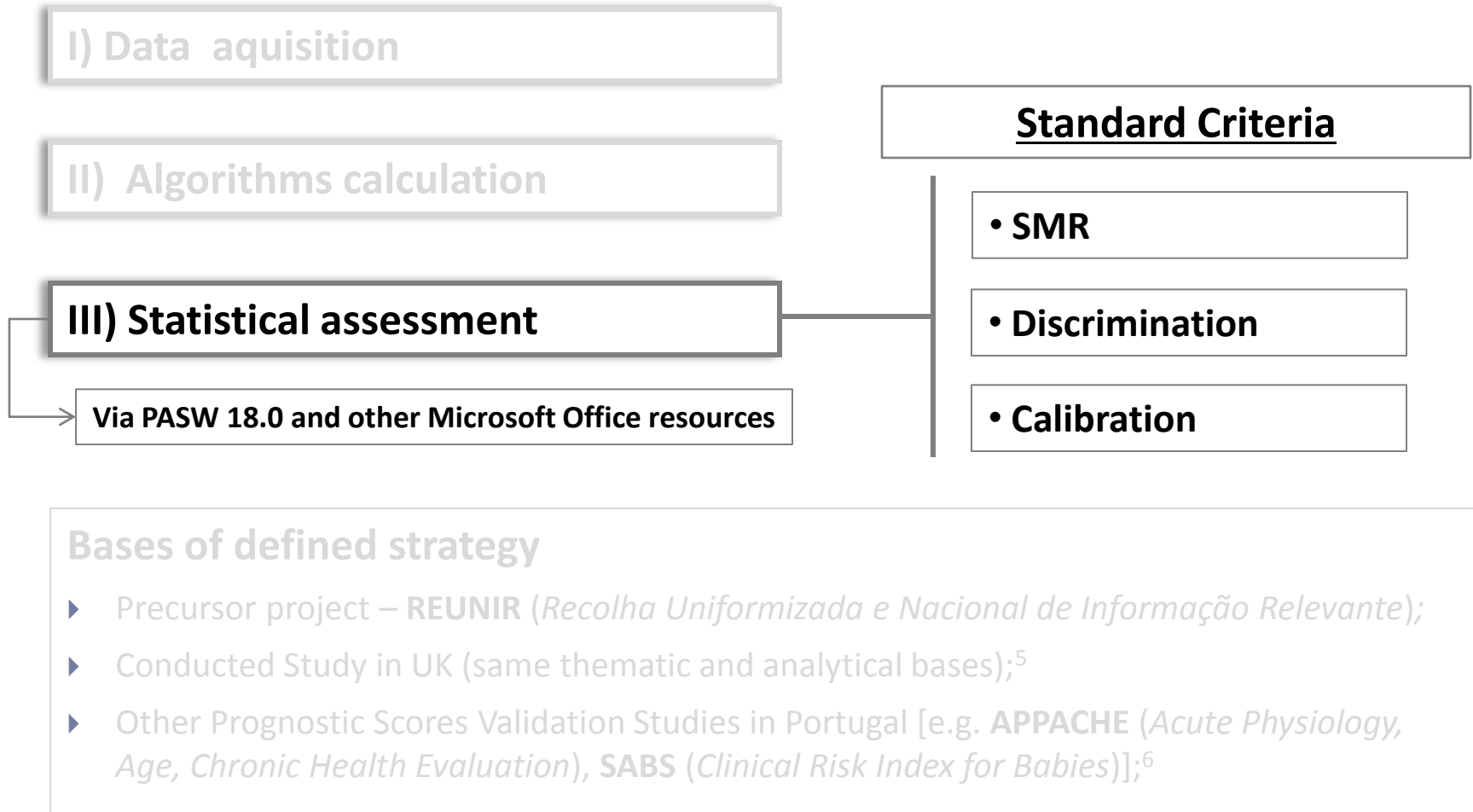
Bases of defined strategy

- ▶ Precursor project – **REUNIR** (*Recolha Uniformizada e Nacional de Informação Relevante*);
- ▶ Conducted Study in UK (same thematic and analytical bases);⁵
- ▶ Other Prognostic Scores Validation Studies in Portugal [e.g. **APPACHE** (*Acute Physiology, Age, Chronic Health Evaluation*), **SABS** (*Clinical Risk Index for Babies*)];⁶

ALGORITHMS CALCULATION

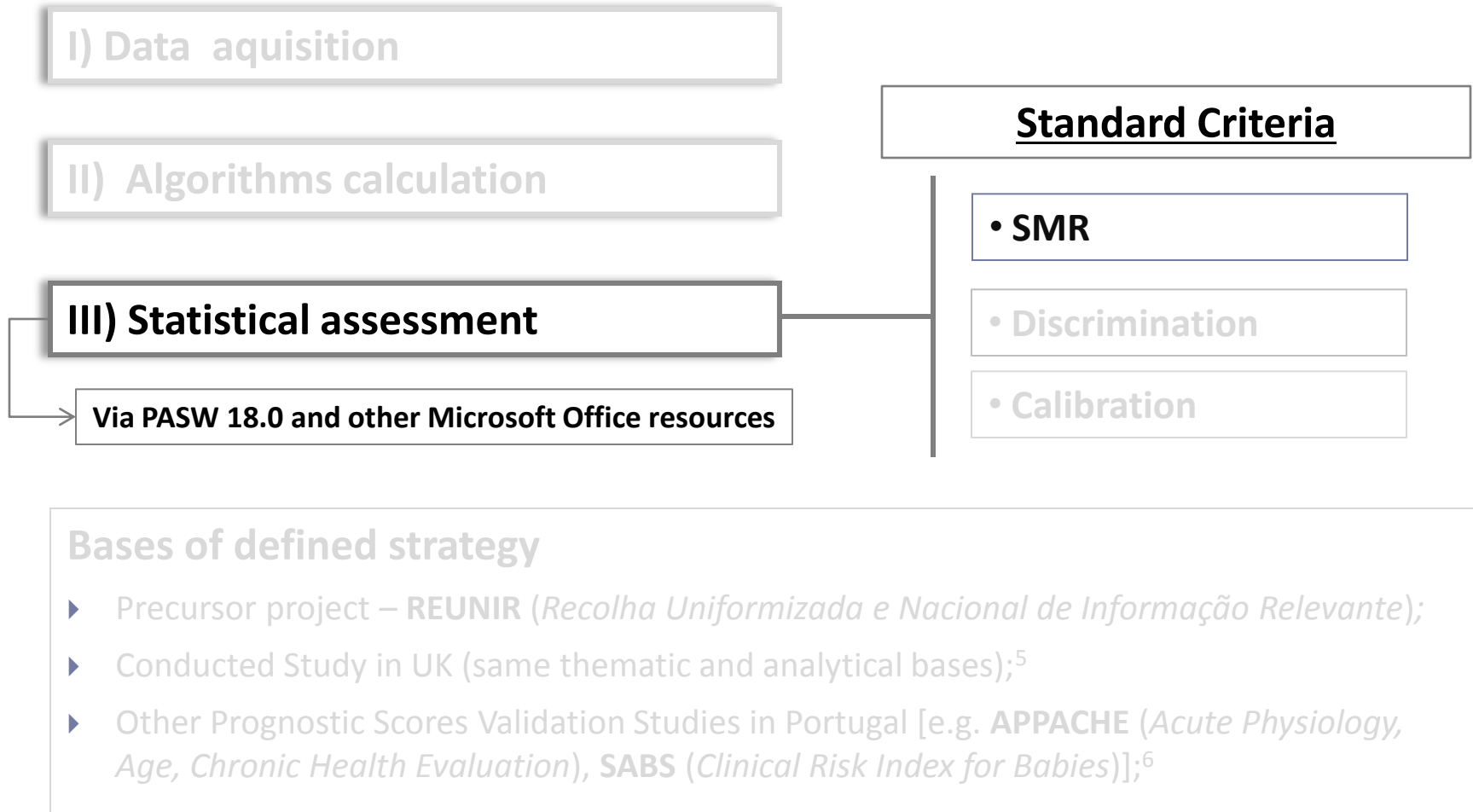
- I) According to **published equations**;
 - II) Informatic **software applications** of Pediatric Mortality Prognostic Scores calculation;
-

STUDY DESIGN



SMR – Standard Mortality Ratio

STUDY DESIGN



SMR – Standard Mortality Ratio

Assessing PICUs quality of care

Comparative Audit purpose

SMR – Standardized Mortality Ratio;

Obtained **by comparing the observed mortality** in the population **with the expected mortality** which could occur once the standard rates applied;

SMR= Number of **observed** deaths / Number of **expected** deaths

It is assumed that:

- **SMR > 1.0** may reflect poor care;
- **SMR <1.0** may reflect good care;

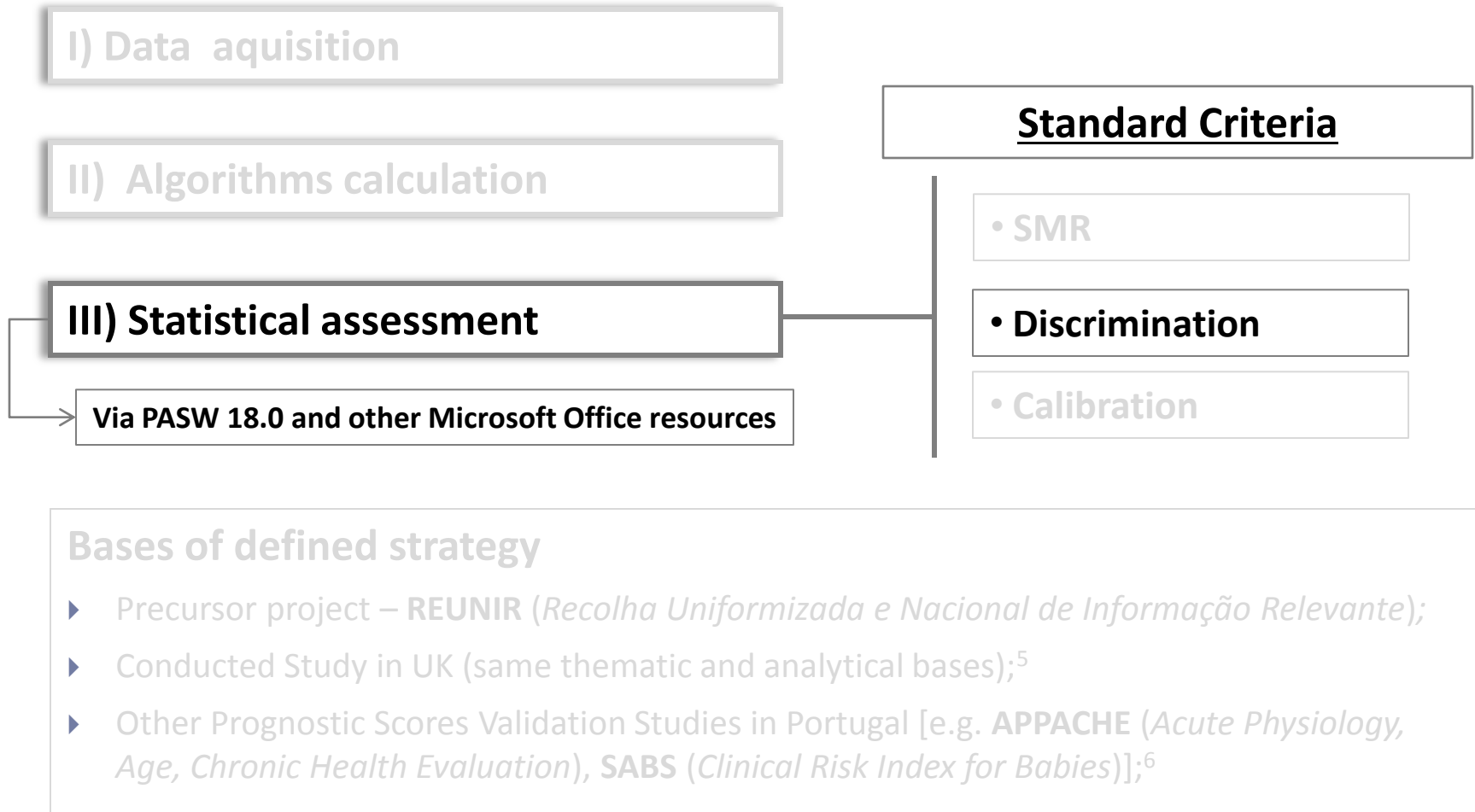
Assessing PICUs quality of care

Comparative Audit purpose

SMR – Standardized Mortality Ratio;

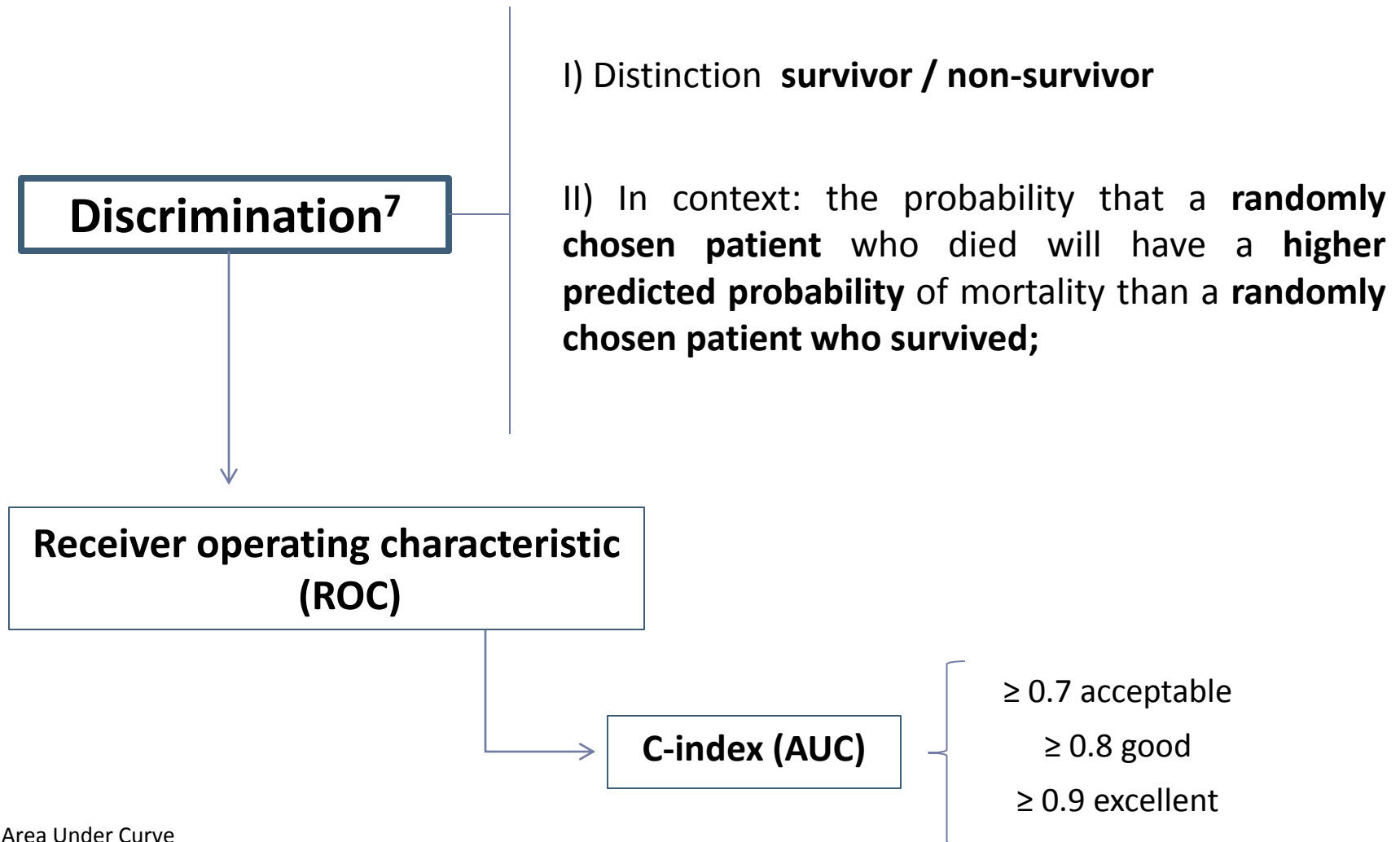
- An indirect mean of **adjusting a rate**;
- **Previous validation studies** as a basilar necessity (relevance of analysis supporting);
- Possibly quoted with an **indication of the uncertainty associated** with its estimation (ex. CI 95% or p-value) – **statistical significance interpretation**;

STUDY DESIGN



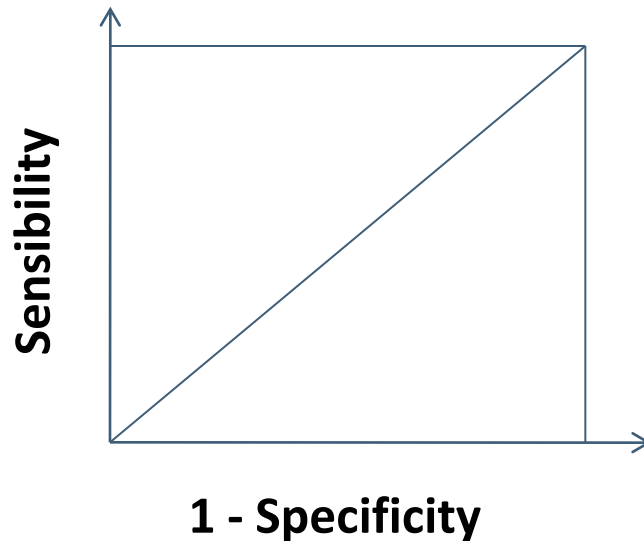
SMR – Standard Mortality Ratio

DISCRIMINATION

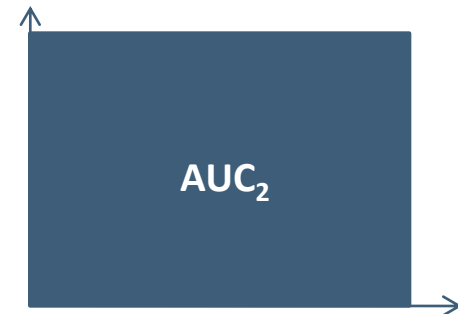


AUC – Area Under Curve

ROC Curves



Lowest discrimination power

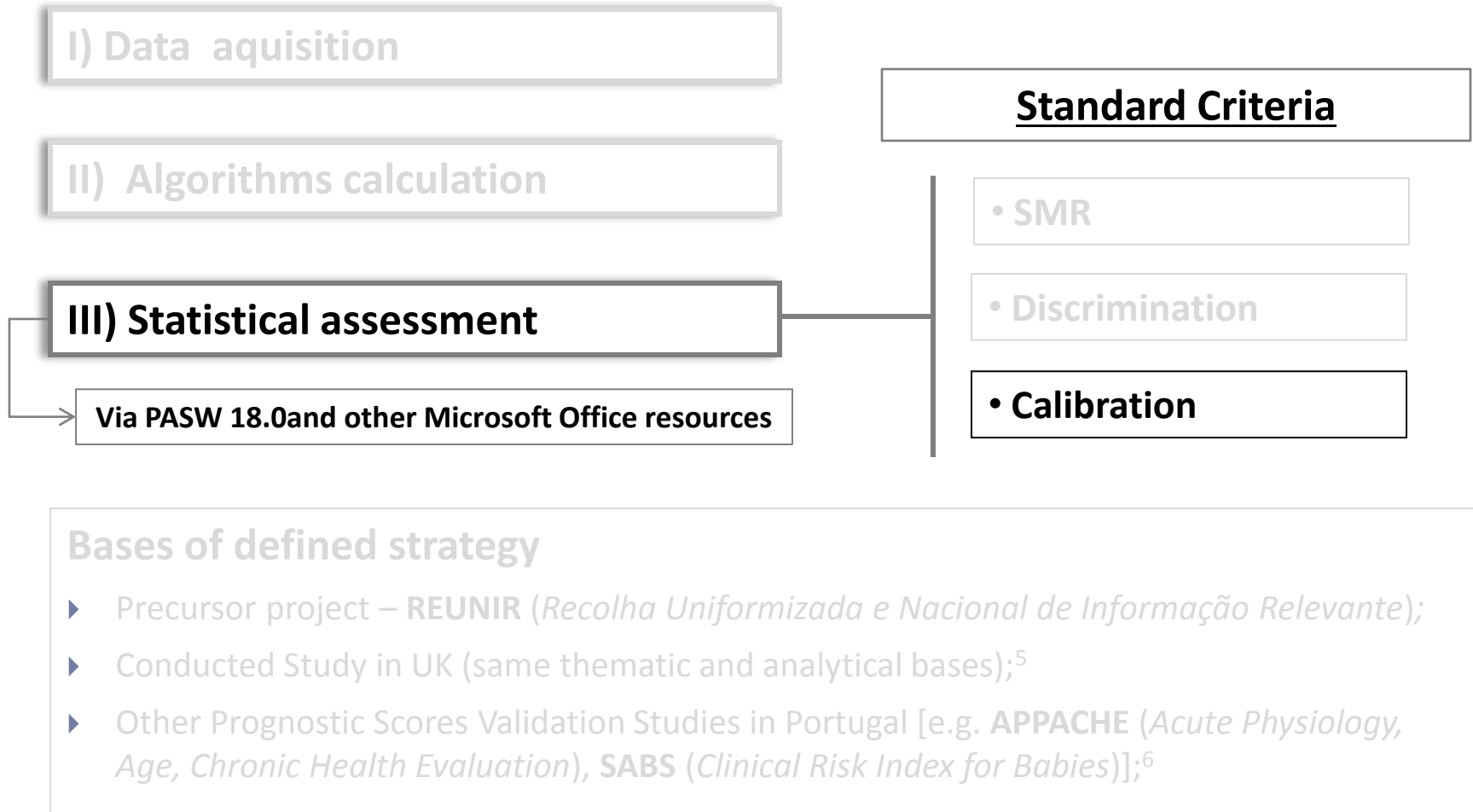


Highest discrimination power

C-index (AUC)²

- ≥ 0.7 acceptable
- ≥ 0.8 good
- ≥ 0.9 excellent

STUDY DESIGN



SMR – Standard Mortality Ratio

Calibration⁸

The ability of a model to **match predictive and observed** death rates across the entire spread of data;

Calibration⁸



Goodness-of-fit Hosmer
Lemeshow test

- I. **Classification** into $g=10$ (or possibly less) decile of **risk groups** based on the values of the **estimated probabilities**;
- II. **Common X^2 test** for the mean of the **predicted probability** against the **observed fraction of events**;
- III. **Null hypothesis:** No differences between observed and expected number of deaths;

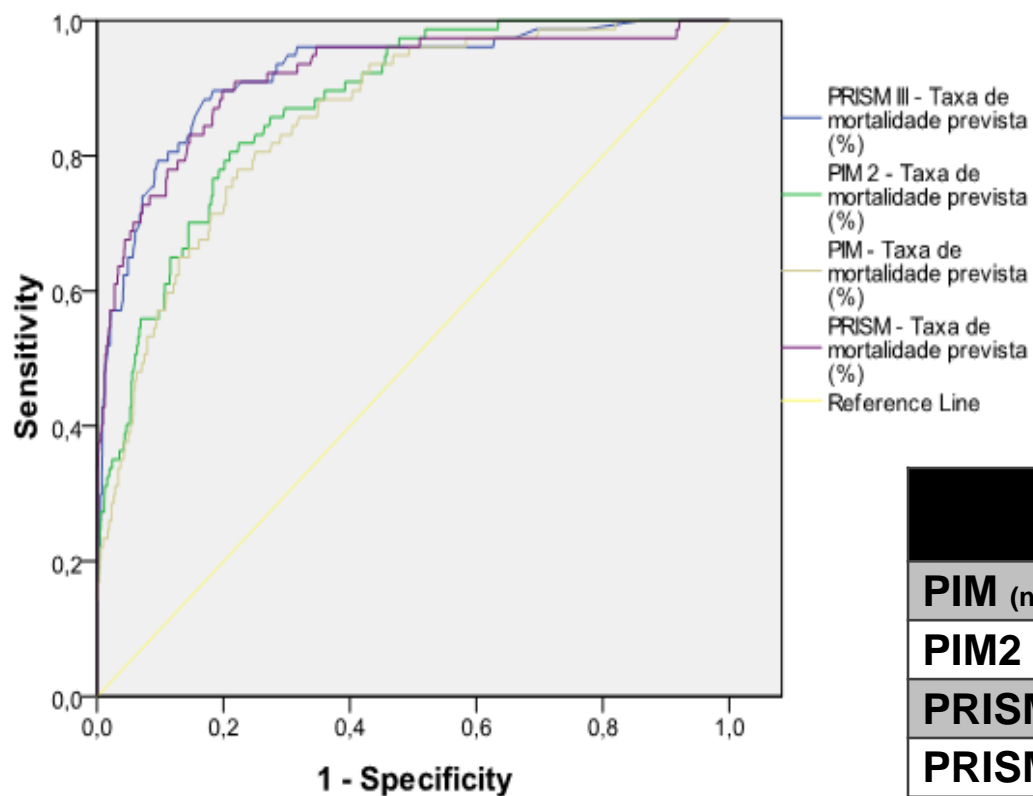
General characteristics of data sample

	Value
Number of patients	1809
Observed mortality (%)	(8.6)
Age – mean (standard deviation)	4.6 (4,83) years
Internament duration – mean (standard deviation)	7.7 (23,0) days
Gender: male (N (%))	977 (54)
Admission reason (%)	
•Surgery	(37.3)
•Medical	(59.9)
•Monitorization and prevention	(2.9)
Mechanical ventilation during internament (%)	(57.4)

RESULTS

Discrimination assessment: Receiver Operating Characteristics

ROC Curve



Score	AUC	CI 95%
PIM (n = 1809)	0,84	[0,81;0,87]
PIM2 (n = 1809)	0,89	[0,85;0,92]
PRISM (n = 1809)	0,90	[0,87;0,92]
PRISM III (n = 1809)	0,91	[0,88;0,93]

PRISM - Pediatric Risk of Mortality; PIM – Pediatric Index of Mortality; AUC – Area under curve

Calibration assessment: Hosmer-Lemeshow goodness-of-fit test

PRISM III – An example

Contingency Table for Hosmer and Lemeshow Test

	Estado clínico na alta da UCIP = Vivo		Estado clínico na alta da UCIP = Falecido		Total
	Observed	Expected	Observed	Expected	
Step 1 1	185	179,451	0	5,549	185
2	181	176,487	1	5,513	182
3	188	184,218	2	5,782	190
4	180	175,419	1	5,581	181
5	179	175,318	2	5,682	181
6	178	173,188	1	5,812	179
7	168	172,756	11	6,244	179
8	164	172,627	16	7,373	180
9	152	165,317	26	12,683	178
10	77	77,220	81	80,780	158

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	51,877	8	,000

Significance level: $p < 0,05$

Calibration assessment: Hosmer-Lemeshow goodness-of-fit test

PRISM III – After categorization

Contingency Table for Hosmer and Lemeshow Test

		Estado clínico na alta da UCIP = Vivo		Estado clínico na alta da UCIP = Falecido		Total
		Observed	Expected	Observed	Expected	
Step 1	1	900	897,499	6	8,501	906
	2	455	459,121	19	14,879	474
	3	173	172,836	19	19,164	192
	4	124	122,545	97	98,455	221

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	1,961	2	,375

Significance level – $p < 0,05$

RESULTS

Summarizing:

Expected mortality

Score	Mean (CI 95%)	AUC	Chi-square (8df)	p-value
PIM (n = 1809)	6,0 (5,3-6,8)	0,84	4,05	0,132
PIM2 (n = 1809)	5,3 (4,5-6,1)	0,89	7,23	0,027
PRISM (n = 1809)	9,9 (8,7-11,1)	0,9	3,62	0,305
PRISM III (n = 1809)	7,4 (6,4-8,4)	0,91	1,96	0,375

AUC – Area Under Curve; PRISM - Pediatric Risk of Mortality; PIM – Pediatric Index of Mortality;

RESULTS

Analysis by PICU at a glance

PICU	Score	Observed mortality rate	Expected mortality rate	SMR
A	PIM	8,2	6,7	1,22
	PIM-2	8,2	5,7	1,44
	PRISM	8,2	10,2	0,80
	PRISM III	8,2	7,2	1,14
B	PIM	5,5	4,8	1,15
	PIM-2	5,5	3,8	1,45
	PRISM	5,5	5,3	1,04
	PRISM III	5,5	4,3	1,28
C	PIM	12,4	8,8	1,41
	PIM-2	12,4	8,2	1,51
	PRISM	12,4	15,3	0,81
	PRISM III	12,4	11,5	1,08

PRISM - Pediatric Risk of Mortality; PIM – Pediatric Index of Mortality; PICU – Pediatric Intensive Care Unit ; SMR – Standardized mortality ratio

RESULTS

Analysis by PICU at a glance

PICU	Score	Discrimination	Calibration	
		Area Under ROC Curve (AUC)	Hosmer-Lemeshow Test	
			Chi-Square (8df)	Significance (p)
A	PIM	0.79	0,78	0,68
	PIM-2	0.84	3,81	0,149
	PRISM	0.91	3,43	0,329
	PRISM III	0.89	0,31	0,985
B	PIM	0.85	10,10	0,006
	PIM-2	0.90	1,94	0,379
	PRISM	0.89	0,19	0,667
	PRISM III	0.91	0,88	0,645
C	PIM	0.88	1,67	0,434
	PIM-2	0.93	12,06	0,006
	PRISM	0.84	2,79	0,425
	PRISM III	0.91	3,74	0,291

PRISM - Pediatric Risk of Mortality; PIM – Pediatric Index of Mortality; PICU – Pediatric Intensive Care Unit

RESULTS

Analysis for case-mix: Planned / Unplanned admission

Type of admission	Score	Discrimination	Calibration	
		Area Under ROC Curve (AUC)	Hosmer-Lemeshow Test	
			Chi-Square (8df)	Significance (p)
Planned	PIM	0.70	0,31	0,577
	PIM-2	0,99	3,81	0,149
	PRISM	0.86	0,36	0,549
	PRISM III	0.95	0,85	0,357
Unplanned	PIM	0.77	7,37	0,069
	PIM-2	0.81	4,26	0,239
	PRISM	0.85	4,22	0,239
	PRISM III	0.86	1,43	0,702

PRISM - Pediatric Risk of Mortality; PIM – Pediatric Index of Mortality; PICU – Pediatric Intensive Care Unit

RESULTS

Analysis for case-mix: Diagnostic group

Causa principal de admissão na UCIP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Insuficiência hepática aguda ou crónica	47	2,6	47,0	47,0
	Asma	1	,1	1,0	48,0
	Bronquiolite	36	2,0	36,0	84,0
	Croup	8	,4	8,0	92,0
	Apneia do sono (obstrutiva)	8	,4	8,0	100,0
	Total	100	5,5	100,0	
Missing	NA - Não aplicavel	102	5,6		
	SI - Sem informação	1607	88,8		
	<u>Total</u>	1709	94,5		
Total		1809	100,0		

RESULTS

Analysis for case-mix: Diagnostic group

Discrimination			Calibration	
Diagnostic Group	Score	Area Under ROC Curve (AUC)	Hosmer-Lemeshow Test	
			Chi-Square (8df)	Significance (p)
Liver failure (acute and cronic)	PIM	0.97	0,00	1,00
	PIM-2	0.86	0,37	0,832
	PRISM	0.83	1,21	0,751
	PRISM III	0.89	1,40	0,496
Not aplicable	PIM	0.85	0,00	1,000
	PIM-2	0.99	1,94	0,379
	PRISM	0.99	0,00	1,000
	PRISM III	1,00	0,00	1,000
Without information	PIM	0.81	3,58	0,167
	PIM-2	0.86	7,18	0,028
	PRISM	0.88	2,54	0,468
	PRISM III	0.89	2,26	0,323

PRISM - Pediatric Risk of Mortality; PIM – Pediatric Index of Mortality; PICU – Pediatric Intensive Care Unit

RESULTS

Correlation assesement

	PRISM III - Taxa de mortalidade prevista (%)	PIM 2 - Taxa de mortalidade prevista (%)	PIM - Taxa de mortalidade prevista (%)	PRISM - Taxa de mortalidade prevista (%)
Pearson Correlation		0,751**	0,702**	0,826**
PRISM III - Taxa de mortalidade prevista (%)				
N		1119	1760	1793
Pearson Correlation	0,751**		0,925**	0,655**
PIM 2 - Taxa de mortalidade prevista (%)				
N	1119		1131	1119
Pearson Correlation	0,702**	0,925**		0,608**
PIM - Taxa de mortalidade prevista (%)				
N	1760	1131		1760
Pearson Correlation	0,826**	0,655**	0,608**	
PRISM - Taxa de mortalidade prevista (%)				
N	1793	1119	1760	

** . Correlation is significant at the 0.01 level (2-tailed).

PIM – Pediatric Index of Mortality; PRISM – Pediatric Risk of Mortality

Correlation assesement

		PRISM III - Taxa de mortalidade prevista (%)	PIM 2 - Taxa de mortalidade prevista (%)	PIM - Taxa de mortalidade prevista (%)	PRISM - Taxa de mortalidade prevista (%)
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	N		1119	1760	1793
	Pearson Correlation	0,751**		0,925**	0,655**
	N	1119		1131	1119
	Pearson Correlation	0,702**	0,925**		0,608**
	N	1760	1131		1760
	Pearson Correlation	0,826**	0,655**	0,608**	
	N	1793	1119	1760	

**. Correlation is significant at the 0.01 level (2-tailed).

1) Good general performance

Good discrimination power ($AUC > 0,8$);
Well calibrated ($p > 0,05$);

2) Poor calibration of PIM2 ($p < 0,05$), although with a good discrimination power;

3) Better general performance in mortality prediction of patients admitted with prior planning

Good general discrimination powers ($0,7 < AUC < 0,99$)
Well calibrated ($p > 0,05$)

4) Limited information available for scores performance analysis by patients diagnostic group;

5) Stronger correlation between scores belonging to **the same score family**;

C-PIM2: A BETTER FITTING?

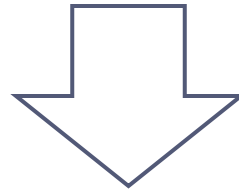
Optimization of PIM2 – an additional purpose

Why?

- **Good** discriminatory power;
- **Poor** calibration;
- Bibliographic evidences: **better performance of PIM2** when compared with PIM;

How?

- **Binary Logistic Regression** with base on Portuguese data;
- **Re-estimation** of algorithm **coefficients** for Portuguese PICU's in developmental sample;



An optimized version for Portuguese reality of PIM2 score

C-PIM2: A BETTER FITTING?

Optimization of PIM2 – an additional purpose

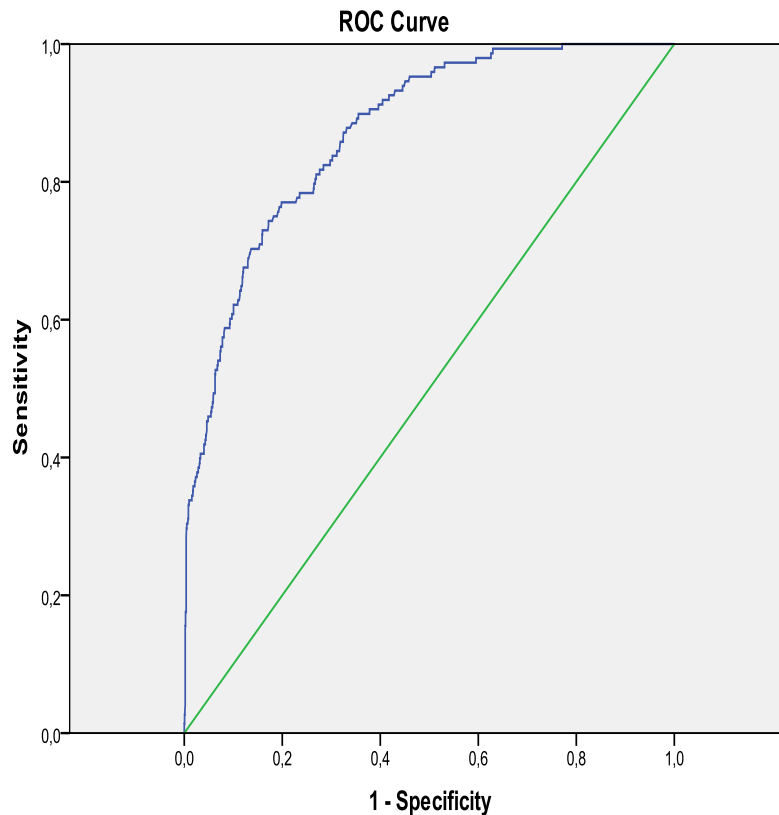
Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	PIM2_A	1,067	,216	24,338	1	,000	2,907
	PIM2_B	-1,298	,438	8,771	1	,003	,273
	PIM2_C	-2,055	,638	10,361	1	,001	,128
	PIM2_D	-18,230	40192,970	,000	1	1,000	,000
	PIM2_E	,654	,220	8,874	1	,003	1,923
	PIM2_F	-,008	,004	3,792	1	,051	,992
	PIM2_H	-,021	,019	1,131	1	,288	,980
	PIM2_I	3,200	,505	40,163	1	,000	24,532
	PIM2_J	-2,226	1,048	4,514	1	,034	,108
	PIM2_GRec	-,046	,329	,020	1	,888	,955
	Constant	-1,926	,455	17,918	1	,000	,146

a. Variable(s) entered on step 1: PIM2_A, PIM2_B, PIM2_C, PIM2_D, PIM2_E, PIM2_F, PIM2_H, PIM2_I, PIM2_J, PIM2_GRec.

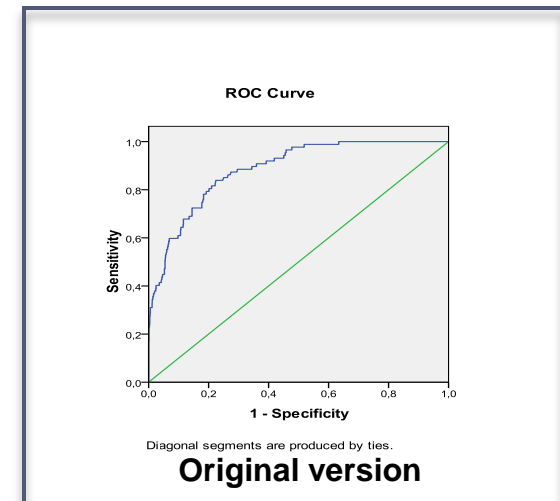
Re-estimated coefficients for optimized version construction

C-PIM2: A BETTER FITTING?

Optimized portuguese PIM2 version discrimination analysis



Diagonal segments are produced by ties.



Area Under the Curve

Test Result Variable(s): Predicted Probability PIM2 T4 (%)

Area	Asymptotic 95% Confidence Interval	
	Lower Bound	Upper Bound
,872	,845	,900

Note: Discrimination analysis on development sample;

C-PIM2: A BETTER FITTING?

Optimized portuguese PIM2 version calibration analysis

Contingency Table for Hosmer and Lemeshow Test

		Estado clínico na alta da UCIP = Vivo		Estado clínico na alta da UCIP = Falecido		Total
		Observed	Expected	Observed	Expected	
Step 1	1	561	559,793	1	2,207	562
	2	257	258,262	6	4,738	263
	3	589	592,420	54	50,580	643
	4	135	131,524	87	90,476	222

Note: Calibration analysis on development sample;

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	1,481	2	,477

Significance level – $p < 0,05$

RESULTS

Summarizing:

Score	Expected mortality (%) Mean (CI 95%)	Area Under ROC Curve (AUC)	Chi-Square (8df)	p-value
PIM (n = 1809)	6,0 (5,3-6,8)	0,84	4,05	0,132
PIM2 (n = 1809)	5,3 (4,5-6,1)	0,89	7,23	0,027
PRISM (n = 1809)	9,9 (8,7-11,1)	0,90	3,62	0,305
PRISM III (n = 1809)	7,4 (6,4-8,4)	0,91	1,96	0,375
C-PIM2 (n = 1809)	8,8 (8,0-9,5)	0,87	1,48	0,477

PRISM - Pediatric Risk of Mortality; PIM – Pediatric Index of Mortality;

CONCLUSION

- **Comparable performance at the prognostic evaluation** of the pediatric patients admitted at a general Portuguese PICU (exception of PIM2);
- Both **discrimination and calibration** are important for determining the adjustment capacity of a model. **Which function is most important** will depend on **the objective** for which the prognostic score is being used.
- Risk-adjustment methods developed primarily in other countries **require validation before being used** to provide risk-adjusted outcomes of PICU mortality for **units within a new health care setting**;

CONCLUSION

- The necessity of an **internal optimization procedure – increment of performance;**
- The importance of these tools **be used to monitor outcome and to improve the quality** of pediatric intensive care within Portugal;
- The importance of a **reliable and so complete as possible** data collection procedure;

- 1) C-PIM2: An external validation study**
- 2) Development and assessment of a new prognostic score for using in mortality prediction in Portuguese general pediatric intensive care units**
- 3) Development of a model of evaluation and estratification of degree of illness severity with base on health state (morbidity) after admission in a portuguese PICU;**

1) C- PIM2: An External validation

- **Coefficients re-estimation** by logistic regression **on data sample used to fit the model (developmental sample);**
- Performance assessment with base on **model prediction for developmental sample;**



A diagram illustrating the concept of inherent bias in external validation. It starts with a list of two points. A horizontal arrow points from the first point to a vertical line. From this line, a horizontal arrow points to the text 'Inherent Bias'. Below this, a large downward-pointing arrow leads to a box containing the conclusion. The text 'Inherent Bias' is underlined.

Inherent Bias

- The same sample on model fitting and in mortality prediction

Basilar necessity of external validation sample

1) C- PIM2: An External validation

How?

1) External data sampling;

Model prediction;

New performance assessment;

VS

2) Alleatory binary division of data sample (Developmental sample / External validation sample)

Model prediction on External validation sample;

New performance assessment;

2) A new mortality prognostic score development

How?

- **New data collection procedure;**
- **Identification of variables predicting mortality** in Portuguese pediatric intensive care context;
- **Modelation of a new algorithm** capable of calculating death probability for pediatric patients admitted at a general Portuguese PICU;
- **External validation** assessment;

3) Morbidity and services quality in pediatric intensive care

Why?

- **PICU major aim:** to **keep alive patients** with severe disability, in the point of view of fisiological condition;
- **Morbidity as more relevant than mortality** for the comparison of treatment efficacy between groups of patients

How?

- 1) **Data collection:** - Risk factors + Survival on admission;
- Health state, 6 months after admission;
- 2) **Identification of variables determining health quality 6 months after admission;**
- 3) **Algorithm formulation and external validation assessment;**

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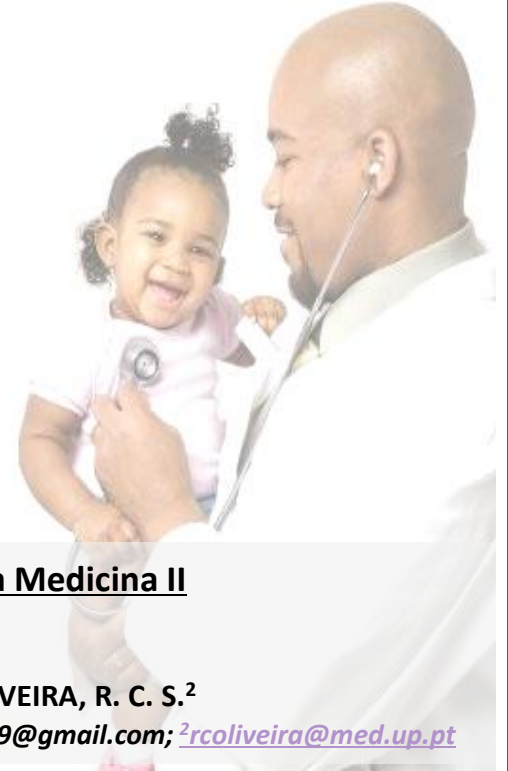
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Performance of Mortality prognostic scores in Portuguese PICU's

"Are they doing a good job?"

THANK YOU!

ANY QUESTIONS?



Introdução à Medicina II

CLASS 4¹

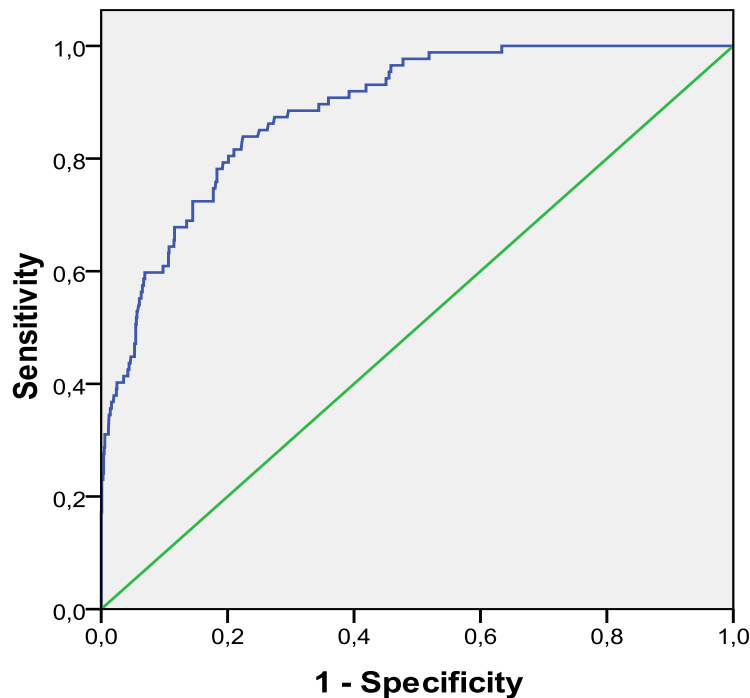
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C-PIM2: A BETTER FITTING?

PIM2: Original version

ROC Curve



Diagonal segments are produced by ties.

PIM – Pediatric Index of Mortality;

Area Under the Curve

Test Result Variable(s):PIM 2 - Taxa de mortalidade prevista (%)

Area	Asymptotic 95% Confidence Interval	
	Lower Bound	Upper Bound
,885	,853	,918

C-PIM2: A BETTER FITTING?

PIM2: Original version

Contingency Table for Hosmer and Lemeshow Test

	Estado clínico na alta da UCIP = Vivo		Estado clínico na alta da UCIP = Falecido		Total
	Observed	Expected	Observed	Expected	
Step 1 1	479	474,505	1	5,495	480
2	392	398,846	23	16,154	415
3	112	112,994	17	16,006	129
4	60	56,655	46	49,345	106

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	7,233	2	,027

Significance level – $p < 0,05$

PIM2 vs C-PIM2

ALGORITHMS

PIM2 – Original Version

$$\text{Logit} = (0.01395 * (\text{ABS}(\text{PIM2_F}))) + (3.0791 * (\text{PIM2_D})) + (0.2888 * (\text{PIM2_GRec})) + (0.104 * (\text{ABS}(\text{PIM2_H}))) + (1.3352 * (\text{PIM2_E})) - (0.9282 * (\text{PIM2_C})) - (1.0244 * (\text{PIM2_B})) + (0.7507 * (\text{PIM2_I})) + (1.6829 * (\text{PIM2_A})) - (1.5770 * (\text{PIM2_J})) - 4.8841$$

$$\text{Predicted Mortality} = e^{\text{Logit}} / (1 + e^{\text{Logit}})$$

C-PIM2 – Portuguese optimized version

$$\text{Logit} = (-0,008 * (\text{ABS}(\text{PIM2_F}))) - (18,230 * (\text{PIM2_D})) - (0,046 * (\text{PIM2_GRec})) - (0,021 * (\text{ABS}(\text{PIM2_H}))) + (0,654 * (\text{PIM2_E})) + (2,055 * (\text{PIM2_C})) + (1,298 * (\text{PIM2_B})) + (3,200 * (\text{PIM2_I})) + (1,067 * (\text{PIM2_A})) + (2,226 * (\text{PIM2_J})) - 1,926$$

$$\text{Predicted Mortality} = e^{\text{Logit}} / (1 + e^{\text{Logit}})$$