Scoring Systems in ICU

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What are the Roles of Scoring Systems?
Roles of Scoring Systems

- Comparative audit
  - Standardised mortality ratio

- Evaluative research
  - Risk stratification

- Clinical management of individual patients
Scoring Systems

- Quantification of case-mix and
- Development of mathematical equations to estimate probabilities of outcome for intensive care patients.
- Outcome parameters:
  - Mortality
  - Morbidity
  - Disability
  - Functional health status
  - Quality of life
What are the Limitations of Scoring Systems?
Limitations of Scoring Systems

1. Generalisibility of scoring system
   - Different patient inclusion criteria
   - Different time period of data collection
   - Different outcome variable
Limitations of Scoring System

3. Accuracy of scoring system
   - Not perfect
   - Different case-mix
   - Score itself not best prediction but the ROD.
Use APACHE II system (SMR) to compare two different ICU performance

Drawbacks
1. Case mix differences
2. Definition of hospital discharge
   - ? Convalescent home
3. Mortality: is it really bad
   - Good death >> 'bad' survival
4. ICU admission policy
   - (esp. with limit no of bed and under hospital policy)
5. Use of admission diagnosis
6. Inter-rater/intra-rate reliability in data entry
7. Electronic data retrieving data
   - (artifact)
8. GCS data entry
   - (Sedation/coma)
Use APACHE II system (SMR) to compare two different ICU performance

Drawbacks

9. Lead time bias
   - (APACHE III better)
10. not just ICU performance
    - Hospital death
    - Post-ICU discharge care
    - Shortage of ICU bed
    - Pre-mature discharge
    - Discharge at odd hours
11. More blood taking
    - ↑ chance of getting worse data
12. Resource put in
    - No of nurses/doctors. Etc.
    - Drugs
    - Consumables and equipments
Use APACHE II system (SMR) to compare two different ICU performance

- Outcome
- Input
- Process
Scoring System Development

- Subjective theoretical approach
  (top-down)
  - experts determine the inclusion of parameters and their weight
    e.g. APACHE, APACHE II, SAPS, TISS

- Objective empirical approach
  (bottom-up)
  - Statistical method to determine factor inclusion and its weight e.g.
    MPM II, APACHE III, APACHE IV
2. Physiologic measurements - From 34 to 12

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<td>+4</td>
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<td>TEMPERATURE — rectal (°C)</td>
<td>≥41*</td>
<td>39*—40.9*</td>
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<td></td>
<td>38.5*—38.4*</td>
<td>36*—38.4*</td>
</tr>
<tr>
<td></td>
<td>32*—33.9*</td>
<td>30*—31.9*</td>
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<td>MEAN ARTERIAL PRESSURE — mm Hg</td>
<td>≥160</td>
<td>140—179</td>
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<td></td>
<td>130—159</td>
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<td></td>
<td>25—34</td>
<td>12—24</td>
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<tr>
<td></td>
<td>6—9</td>
<td>≤5</td>
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<tr>
<td>OXYGENATION: A-aDO₂ or PaO₂ (mm Hg)</td>
<td>≥500</td>
<td>350—499</td>
</tr>
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<td></td>
<td>200—349</td>
<td>&lt;200</td>
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<td></td>
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<td>a. FI₀₂ ≥ 0.5 record A-aDO₂</td>
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<td>≥180</td>
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<td>SERUM POTASSIUM (mMol/L)</td>
<td>≥7</td>
<td>6.5—9</td>
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<td>SERUM CREATININE (mg/100 ml) (Double point score for acute renal failure)</td>
<td>≥3.5</td>
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<td>HEMATOCRIT (%)</td>
<td>≥30</td>
<td>50—59.9</td>
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<td>WHITE BLOOD COUNT (total/mm³) (in 1,000s)</td>
<td>≥40</td>
<td>20—39.9</td>
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<td>GLASGOW COMA SCORE (GCS): Score = 15 minus actual GCS</td>
<td></td>
<td></td>
</tr>
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<td>TOTAL ACUTE PHYSIOLOGY SCORE (APS): Sum of the 12 individual variable points</td>
<td>Serum HCO₃ (venous-mMol/L) (Not preferred, use if no ABGs)</td>
<td>≥52</td>
</tr>
</tbody>
</table>
Fig. 2  APACHE III scoring for vital signs and laboratory abnormalities. (Reproduced with permission from Knaus et al. (1991).)
How to validate a scoring system?
Discrimination

Test the ability to discriminate live and death

Calibration

Hosmer-Lemeshow

Ĉ statistics

Ĥ statistics

Test extent of agreement between expected and observed death across all subgroups of patients

Mathematical Model

(Goodness of fit model)

Scores  →  Risk of Death

Discrimination

ROC

Test the ability to discriminate live and death
Hosmer-Lemeshow Goodness-of-Fit (C test) – Original models

**APACHE II**

<table>
<thead>
<tr>
<th>Predicted Mortality Within Decile (%)</th>
<th># of Admissions</th>
<th>Observed Deaths</th>
<th>Expected Deaths</th>
<th>Observed Survivors</th>
<th>Expected Survivors</th>
<th>H-L Statistic</th>
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<tbody>
<tr>
<td>0.001 - 0.033</td>
<td>468</td>
<td>2</td>
<td>8.9</td>
<td>466</td>
<td>459.1</td>
<td>5.46</td>
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<tr>
<td>0.033 - 0.056</td>
<td>457</td>
<td>9</td>
<td>20.4</td>
<td>448</td>
<td>436.6</td>
<td>6.63</td>
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<tr>
<td>0.056 - 0.081</td>
<td>463</td>
<td>16</td>
<td>31.0</td>
<td>447</td>
<td>432.0</td>
<td>7.74</td>
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<tr>
<td>0.081 - 0.109</td>
<td>465</td>
<td>13</td>
<td>43.9</td>
<td>452</td>
<td>421.1</td>
<td>24.05</td>
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<tr>
<td>0.110 - 0.146</td>
<td>467</td>
<td>32</td>
<td>59.5</td>
<td>435</td>
<td>407.5</td>
<td>14.54</td>
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<tr>
<td>0.146 - 0.201</td>
<td>456</td>
<td>47</td>
<td>78.5</td>
<td>409</td>
<td>377.5</td>
<td>15.24</td>
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<tr>
<td>0.201 - 0.263</td>
<td>462</td>
<td>62</td>
<td>106.2</td>
<td>400</td>
<td>355.8</td>
<td>23.87</td>
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<tr>
<td>0.265 - 0.387</td>
<td>468</td>
<td>85</td>
<td>148.5</td>
<td>383</td>
<td>319.5</td>
<td>39.75</td>
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<tr>
<td>0.389 - 0.577</td>
<td>463</td>
<td>165</td>
<td>220.7</td>
<td>298</td>
<td>242.3</td>
<td>26.84</td>
</tr>
<tr>
<td>0.577 - 0.996</td>
<td>461</td>
<td>279</td>
<td>342.1</td>
<td>182</td>
<td>118.9</td>
<td>45.09</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4630</strong></td>
<td><strong>710</strong></td>
<td><strong>1059.5</strong></td>
<td><strong>3920</strong></td>
<td><strong>3570.5</strong></td>
<td><strong>209.20</strong></td>
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\[ C = 209.20 \quad df 10, \quad p < 0.0001 \]
Hosmer-Lemeshow Goodness-of-Fit (H test) – Original models

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<tr>
<td>0.001 - 0.099</td>
<td>1720</td>
<td>36</td>
<td>90.0</td>
<td>1684</td>
<td>1630.0</td>
<td>34.21</td>
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<tr>
<td>0.100 - 0.199</td>
<td>1052</td>
<td>82</td>
<td>151.2</td>
<td>970</td>
<td>900.8</td>
<td>37.03</td>
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<tr>
<td>0.201 - 0.300</td>
<td>650</td>
<td>95</td>
<td>159.0</td>
<td>555</td>
<td>491.0</td>
<td>34.08</td>
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<tr>
<td>0.300 - 0.399</td>
<td>323</td>
<td>62</td>
<td>111.8</td>
<td>261</td>
<td>211.2</td>
<td>33.96</td>
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<tr>
<td>0.402 - 0.498</td>
<td>267</td>
<td>88</td>
<td>120.3</td>
<td>179</td>
<td>146.7</td>
<td>15.79</td>
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<tr>
<td>0.500 - 0.598</td>
<td>192</td>
<td>80</td>
<td>105.6</td>
<td>112</td>
<td>86.4</td>
<td>13.80</td>
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<tr>
<td>0.602 - 0.699</td>
<td>161</td>
<td>73</td>
<td>103.9</td>
<td>88</td>
<td>57.1</td>
<td>25.95</td>
</tr>
<tr>
<td>0.700 - 0.798</td>
<td>101</td>
<td>66</td>
<td>75.3</td>
<td>35</td>
<td>25.7</td>
<td>4.49</td>
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<tr>
<td>0.801 - 0.898</td>
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<td>0.902 - 0.996</td>
<td>44</td>
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H = 212.70  df 10, p < 0.0001
How to classify scoring systems?
Classification of Scoring systems for ICU

- General
  - TISS, APACHE, SAPS, MPM

- Specific
  - SOFA, MODS: sepsis of multi-organ failure
  - GCS: conscious status
  - TRISS: trauma patient
General scoring systems

- APACHE
  - APACHE II
  - APACHE III
  - APACHE IV
- SAPS
  - SAPS II
  - SAPS 3
- MPM
  - MPM₀
  - MPM₂₄
  - MPM₄₈ & MPM₇₂
APACHE II
APACHE II: A severity of disease classification system

   - 34 physiologic measures (0-4)
     - Sum of all acute physiology scores (APS)
     - Worst of the initial 24 hour after ICU admission
   - Chronic health
     - A  (excellent health)
     - B
     - C
     - D  (severe chronic organ system insufficiency)
   - Complex
   - Need formal multi-institutional validation
2. **Physiologic measurements - From 34 to 12**

![The APACHE II Severity of Disease Classification System Table]

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<td>≥ 52</td>
<td>41-51.9</td>
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2. Physiologic measurements

- A lot of multi-variate comparison of the original variable had been made.

- ↑ weighting for GCS

- Creatinine weighting:
  - Double if acute renal failure

- For FiO₂ < 0.5, direct weighting based on PaO₂ rather than P(A-a) O₂.

- Worst reading over initial 24 hours in ICU.
### APACHE II

3. Age

- Well documented independent risk factor for death

**AGE POINTS:**

Assign points to age as follows:

<table>
<thead>
<tr>
<th>AGE (yrs)</th>
<th>Points</th>
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<tbody>
<tr>
<td>≤ 44</td>
<td>0</td>
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<tr>
<td>45-54</td>
<td>2</td>
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<tr>
<td>55-64</td>
<td>3</td>
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<tr>
<td>65-74</td>
<td>5</td>
</tr>
<tr>
<td>≥75</td>
<td>6</td>
</tr>
</tbody>
</table>
4. Clinical health classification

- Only the original most severe category D markedly influenced the outcome

**C**

**CHRONIC HEALTH POINTS**

If the patient has a history of severe organ system insufficiency or is immuno-compromised assign points as follows:

a. For nonoperative or emergency postoperative patient – 5 points.

**OR**

b. For elective postoperative patient – 2 points
DEFINITIONS

Organ Insufficiency or immuno-compromised state must have been evident prior to this hospital admission and conform to the following criteria:

LIVER: Biopsy proven cirrhosis and documented portal hypertension; episodes of past upper GI bleeding attributed to portal hypertension; or prior episodes of hepatic failure/encephalopathy/coma.

CARDIOVASCULAR: New York Heart Association Class IV.

RESPIRATORY: Chronic restrictive, obstructive, or vascular disease resulting in severe exercise restriction, i.e., unable to climb stairs or perform household duties; or documented chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension (>40 mmHg), or respirator dependency.

RENAL: Receiving chronic dialysis.

IMMUNO-COMPROMISED: The patient has received therapy that suppresses resistance to infection, e.g. immuno-suppression, chemotherapy, radiation, long term or recent high dose steroids, or has a disease that is sufficiently advanced to suppress resistance to infection e.g. leukemia, lymphoma, AIDS.
5. APACHE II score (0 – 71)

A+B+C

**APACHE II SCORE**

Sum of  

<table>
<thead>
<tr>
<th>A</th>
<th></th>
<th>B</th>
<th></th>
<th>C</th>
</tr>
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<tbody>
<tr>
<td>APS points</td>
<td></td>
<td>Age points</td>
<td></td>
<td>Chronic Health points</td>
</tr>
</tbody>
</table>

Total APACHE II
Validation Process

- 13 US hospitals
  - George Washington University Medical Centre: 1979-1981
  - Other 12 hospitals: 1982
- 5815 admissions
7. R: (Risk of hospital death)

\[ \ln(\text{odds of } R) = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + \ldots \]

\[ \ln(\frac{R}{1-R}) = -3.517 + 0.146 \text{ score} \]

+ 0.603 (1 for emergency OT, otherwise 0)

+ (diagnostic category weight)

50 diagnostic categories
APPENDIX

To compute predicted death rates for groups of acutely ill patients, for each individual compute the risk (R) of hospital death with the following equation; then sum the individual risks and divide by the total number of patients.

\[
\ln \left( \frac{R}{1-R} \right) = -3.517 + (\text{APACHE II score} \times 0.146) \\
+ (0.603, \text{only if postemergency surgery}) \\
+ (\text{Diagnostic category weight, as shown below})
\]

Principal Diagnostic Categories Leading to ICU Admission

Nonoperative patients

Respiratory failure or insufficiency from:
- Asthma/allergy: -2.108
- COPD: -0.367
- Pulmonary edema (noncardiogenic): -0.251
- Postrespiratory arrest: -0.168
- Aspiration/poisoning/toxic: -0.142
- Pulmonary embolus: -0.128
- Infection: 0
- Neoplasm: 0.891

Cardiovascular failure or insufficiency from:
- Hypertension: -1.798
- Rhythm disturbance: -1.368
- Congestive heart failure: -0.424
- Hemorrhagic shock/hypovolemia: 0.493
- Coronary artery disease: -0.191
- Sepsis: 0.113
- Postcardiac arrest: 0.393
- Cardiogenic shock: -0.259
- Dissecting thoracic/abdominal aneurysm: 0.731

Trauma:
- Multiple trauma: -1.228
- Head trauma: -0.517

Neurologic:
- Seizure disorder: -0.584
- ICH/SDH/SAH: 0.723

Other:
- Drug overdose: -3.353
- Diabetic ketoacidosis: -1.507
- GI bleeding: 0.334

If not in one of the specific groups above, then which major vital organ system was the principal reason for admission?
- Metabolic/renal: -0.885
- Respiratory: -0.890
- Neurologic: -0.759
- Cardiovascular: 0.470
- Gastrointestinal: 0.501

Postoperative patients

- Multiple trauma: -1.684
- Admission due to chronic cardiovascular disease: -1.376
- Peripheral vascular surgery: -1.315
- Heart valve surgery: -1.261
- Craniotomy for neoplasm: -1.245
- Renal surgery for neoplasm: -1.204
- Renal transplant: -1.042
- Head trauma: -0.955
- Thoracic surgery for neoplasm: -0.802
- Craniotomy for ICH/SDH/SAH: -0.788
- Laminctomy and other spinal cord surgery: -0.699
- Hemorrhagic shock: -0.682
- GI bleeding: -0.617
- GI surgery for neoplasm: -0.248
- Respiratory insufficiency after surgery: -0.140
- GI perforation/obstruction: 0.060

For postoperative patients admitted to the ICU for sepsis or postarrest, use the corresponding weights for nonoperative patients.

If not in one of the above, which major vital organ system led to ICU admission post surgery?
- Neurologic: -1.150
- Cardiovascular: -0.797
- Respiratory: -0.610
- Gastrointestinal: -0.613
- Metabolic/renal: -0.196
For Example: A patient admitted with noncardiogenic pulmonary edema (nonoperative) having 15 APACHE II points would have the following estimated risk:

\[
\text{In (R/1-R)} = -3.517 + (15 \times 0.146) + (0 \times 0.603) - 0.251 = -3.517 + 2.19 + 0 - 0.251 = -1.578
\]

Since the exponential of –1.578 is +0.206, then (R/1-R) equals +0.206, and R is 0.17 or 17% estimated risk of hospital death.
APACHE III
APACHE III
Knaus WA et al, Chest 1991, 100:1619 - 1636

- Developed in 1991
- Data collected in 1988 to 1990
- 17,440 admissions in US hospitals
- Involved 42 ICUs at 40 hospitals
APACHE III

- Re-evaluate the selection & weighting of physiological variables
- Update & expand the size & representativeness of reference database
- Examine relationship between outcome & patients selection for & timing of intensive care admission
- Distinguish the use of predictive estimates for patient groups from mortality estimates for individual patients
APACHE III

- 17 physiological variables
- Acid-base disturbances
- GCS score – based on the worst
  - Weighting adjusted for interactions between occular, verbal and motor responses
- Age score
- 7 comorbidities (cardiac, respiratory and renal failures excluded)
- Total score (0 – 299)
Fig. 2  APACHE III scoring for vital signs and laboratory abnormalities. (Reproduced with permission from Knaus et al. (1991).)
### APACHE III

Eyes open spontaneously or to painful/verbal stimulation

<table>
<thead>
<tr>
<th>Motor</th>
<th>Verbal</th>
<th>Oriented</th>
<th>Confused conversation</th>
<th>Inappropriate words and incomprehensible sounds</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obeys verbal command</td>
<td>0</td>
<td>3</td>
<td>10</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Localizes pain</td>
<td>3</td>
<td>8</td>
<td>13</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Flexion withdrawal / decorticate rigidity</td>
<td>3</td>
<td>13</td>
<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Decerebrate rigidity / no response</td>
<td>3</td>
<td>13</td>
<td>29</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

The shaded areas without scores represent unusual and unlikely clinical combinations. There were few or no cases in these cells. For the shaded areas with scores we had data that permit us to extrapolate values. Placing a patient in any of these cells should be done after careful confirmation of clinical findings.
### APACHE III

<table>
<thead>
<tr>
<th>Motor</th>
<th>Verbal Commands</th>
<th>Oriented</th>
<th>Confused Conversation</th>
<th>Inappropriate words and incoherent sounds</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyes do not open spontaneously or to painful/verbal stimulation</td>
<td></td>
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</tr>
<tr>
<td>Obeys verbal command</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Localizes pain</td>
<td></td>
<td></td>
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<td></td>
<td>16</td>
</tr>
<tr>
<td>Flexion withdrawal / decorticate rigidity</td>
<td></td>
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<td>24</td>
</tr>
<tr>
<td>Decerebrate rigidity / no response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>29</td>
</tr>
</tbody>
</table>

The shaded areas without scores represent unusual and unlikely clinical combinations. There were few or no cases in these cells. For the shaded areas with scores we had data that permit us to extrapolate values. Placing a patient in any of these cells should be done after careful confirmation of clinical findings.
### APACHE III Scoring for Acid-Base Disturbances

<table>
<thead>
<tr>
<th>pH</th>
<th>$P_{CO_2}$</th>
<th>&lt; 25</th>
<th>25-&lt;30</th>
<th>30-&lt;35</th>
<th>35-&lt;40</th>
<th>40-&lt;45</th>
<th>45-&lt;50</th>
<th>50-&lt;55</th>
<th>55-&lt;60</th>
<th>≥ 60</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;7.15</td>
<td>12</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td>4</td>
</tr>
<tr>
<td>7.15-&lt;7.2</td>
<td></td>
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<tr>
<td>7.20-&lt;7.25</td>
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<td>2</td>
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<tr>
<td>7.25-&lt;7.30</td>
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<td>7.30-&lt;7.35</td>
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<td>7.35-&lt;7.40</td>
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<tr>
<td>7.40-&lt;7.45</td>
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<td>1</td>
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<td>2</td>
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<tr>
<td>7.50-&lt;7.55</td>
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<tr>
<td>7.55-&lt;7.60</td>
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<td>12</td>
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<tr>
<td>7.60-&lt;7.65</td>
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<tr>
<td>≥ 7.65</td>
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<tr>
<td>Age (years)</td>
<td>Count</td>
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<td>45-59</td>
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<tr>
<td>60-64</td>
<td>11</td>
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<td>65-69</td>
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<td>70-74</td>
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<td>75-85</td>
<td>17</td>
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<td>≥85</td>
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</tbody>
</table>
## Chronic health evaluation (Comorbid condition)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>AIDS</td>
<td>23</td>
</tr>
<tr>
<td>Hepatic failure</td>
<td>16</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>13</td>
</tr>
<tr>
<td>Metastatic cancer</td>
<td>11</td>
</tr>
<tr>
<td>Leukemia/multiple myeloma</td>
<td>10</td>
</tr>
<tr>
<td>Immunosuppression</td>
<td>10</td>
</tr>
<tr>
<td>Cirrhosis</td>
<td>4</td>
</tr>
</tbody>
</table>
APACHE III

- Predictive equations
  - 1988 - 1990 (17,440) (version H)
  - 1993 – 1996 (>37,000) (version I)
- 66 specific diagnosis and 12 organ-system related categories
- ICU re-admission
- Emergency surgery
- Location prior to ICU admission
- Hospital LOS and location prior to ICU admission
APACHE III

- Hospital mortality
- Intensive care resource use
  - ICU/hospital LOS
  - Risk of active life supporting therapy
  - Frequency of lab testing
  - Duration of mechanical ventilation
APACHE III

- Prognosis of individual patient
- Hospital mortality is updated daily
  - Day 1 score
  - Physiological status during the current day
  - Physiological trends in previous 24 hours
APACHE III

- Expensive
APACHE IV
APACHE IV

- Published in 2006
- 2002 – 2003 (131,618 ICU admissions)
- 104 ICUs in 45 US hospitals
APACHE IV

- Age
  - continuous measure + 5 spline terms
- APS
  - ~ APACHE III + 5 spline terms
- Comorbidities
  - ~ APACHE III (not for elective surgery patients)
- ICU admission diagnosis
  - 116 categories (vs 78 in APACHE III & 50 in APACHE II)
APACHE IV

- ICU admission source
  - Floor, A&ED, OT, HDU, direct admission, other ICU, other hospital, others
- LOS before ICU admission
  - Square root + 4 spline terms
- Emergency OT
- Unable to assess GCS
- Thrombolytic therapy for AMI
- Mechanical ventilation
- Rescaled GCS (15 - GCS)
- PaO2/FiO2 ratio
APACHE IV

- Spline terms for age, APS and prior LOS
  - Allow for nonlinear relationships with outcomes
  - Replace logit(odds) = $b_0 + b_1x_1 + b_2x_2 + ...$

- www.criticaloutcomes.cerner.com

- Discrimination
  - Area under ROC

- Calibration
  - Cox chi-square test
  - Hosmer-Lemeshow C statistic
Risk of Death with APS

Graph showing the relationship between APS and Risk of Death.
APACHE IV

Risk of Death with Age

Risk of Death

Age
APACHE IV

Risk of Death with Previous LOS

Risk of Death

Previous Length of Stay in hours
Table 4. Comparison of discrimination and calibration of the Acute Physiology and Chronic Health Evaluation (APACHE) IV mortality model and earlier APACHE III versions when applied to the same 2002–2003 validation data set (n = 44,288)

<table>
<thead>
<tr>
<th>Version</th>
<th>APACHE IV$^a$</th>
<th>APACHE III—Version I$^b$</th>
<th>APACHE III—Version H$^c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed mortality rate, %</td>
<td>13.51</td>
<td>13.51</td>
<td>13.51</td>
</tr>
<tr>
<td>Predicted mortality rate, %</td>
<td>13.55</td>
<td>14.64</td>
<td>16.90</td>
</tr>
<tr>
<td>SMR, observed/predicted</td>
<td>0.997 ($p = .79$)</td>
<td>0.923 ($p &lt; .001$)</td>
<td>0.799 ($p &lt; .001$)</td>
</tr>
<tr>
<td>Area under the ROC curve</td>
<td>0.880</td>
<td>0.870</td>
<td>0.868</td>
</tr>
<tr>
<td>Hosmer-Lemeshow $\chi^2$</td>
<td>16.8 ($p = .08$)</td>
<td>124.6 ($p &lt; .001$)</td>
<td>635.4 ($p &lt; .001$)</td>
</tr>
</tbody>
</table>

ROC, receiver operating characteristic curve.

$^a$APACHE IV was validated using data for 44,288 admissions to 104 intensive care units during 2002 and 2003; $^b$APACHE III version I was developed using data for 40,264 admissions to 188 intensive care units during 1993 and 1996 (unpublished data); $^c$APACHE III version H was developed using data for 16,662 admissions to 42 intensive care units during 1988 and 1989 (Refs. 2, 23).
APACHE IV

- Mech. Vent., 0.6%
- Diagnosis, 16.5%
- Admission Variables, 2.9%
- Chronic Health Items, 5.0%
- Age, 9.4%
- Acute Physiology, 65.6%
APACHE IV
### Table 7. Standardized mortality ratio for selected disease groups when Acute Physiology and Chronic Health Evaluation (APACHE) IV, APACHE III version I, and APACHE III version H predictions are used for the 2002–2003 validation data set (n = 44,288)

<table>
<thead>
<tr>
<th>Disease Group</th>
<th>No.</th>
<th>Observed Mortality, %</th>
<th>APACHE IV&lt;sup&gt;a&lt;/sup&gt;</th>
<th>APACHE III Version I&lt;sup&gt;b&lt;/sup&gt;</th>
<th>APACHE III Version H&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Predicted Mortality, %</td>
<td>SMR</td>
<td>Predicted Mortality, %</td>
</tr>
<tr>
<td>Sepsis (nonurinary tract)</td>
<td>1,821</td>
<td>37.3</td>
<td>37.4</td>
<td>1.00</td>
<td>41.8</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>872</td>
<td>58.3</td>
<td>58.4</td>
<td>1.00</td>
<td>53.1</td>
</tr>
<tr>
<td>Emphysema/bronchitis</td>
<td>878</td>
<td>15.1</td>
<td>13.4</td>
<td>1.13</td>
<td>17.4</td>
</tr>
<tr>
<td>Noncardiac pulmonary edema (ARDS)</td>
<td>310</td>
<td>27.7</td>
<td>28.2</td>
<td>0.98</td>
<td>36.3</td>
</tr>
<tr>
<td>Thoracotomy for lung neoplasm</td>
<td>633</td>
<td>4.1</td>
<td>4.3</td>
<td>0.96</td>
<td>3.5</td>
</tr>
<tr>
<td>Aortic aneurysm, elective repair</td>
<td>701</td>
<td>5.6</td>
<td>4.7</td>
<td>1.19</td>
<td>3.9</td>
</tr>
<tr>
<td>Stroke</td>
<td>860</td>
<td>21.5</td>
<td>20.2</td>
<td>1.06</td>
<td>19.8</td>
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<tr>
<td>Hepatic failure</td>
<td>236</td>
<td>45.8</td>
<td>41.4</td>
<td>1.11</td>
<td>47.4</td>
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<tr>
<td>Respiratory arrest</td>
<td>490</td>
<td>34.1</td>
<td>32.2</td>
<td>1.06</td>
<td>35.3</td>
</tr>
</tbody>
</table>

SMR, standardized mortality ratio; ARDS, acute respiratory distress syndrome.

<sup>a</sup>APACHE IV was validated using data for 44,288 admissions to 104 intensive care units during 2002 and 2003.

<sup>b</sup>APACHE III version I was developed using data for 40,264 admissions to 188 intensive care units during 1993 and 1996 (unpublished data).

<sup>c</sup>APACHE III version H was developed using data for 1,662 admissions to 42 intensive care units during 1988 and 1989 (Refs. 2, 23).

<sup>d</sup>p < .001; <sup>e</sup>p < .01.
SAPS II
SAPS II
Legall JR et al, JAMA 1993, 270:2957 - 2963

- 12,997 patients
- Europe & North America ICUs
SAPS II

- Simple
- 12 physiological variables
  - no venous/arterial blood gases needed
- Age
- Types of admission
  - scheduled OT, unscheduled OT, medical
- Chronic diseases
  - AIDS, metastatic cancer & haematologic malignancy
- No disease category needed
### SAPS II

<table>
<thead>
<tr>
<th>Variable/Points</th>
<th>26</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>9</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>7</th>
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<th>10</th>
<th>12</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>&lt;40</td>
<td>40–69</td>
<td>70–119</td>
<td>≥120–159</td>
<td>≥160</td>
<td>60–69</td>
<td>70–74</td>
<td>75–79</td>
<td>≥80</td>
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<tr>
<td>Heart rate (beats/min)</td>
<td>&lt;40</td>
<td>40–69</td>
<td>70–119</td>
<td>≥120–159</td>
<td>≥160</td>
<td>60–69</td>
<td>70–74</td>
<td>75–79</td>
<td>≥80</td>
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<tr>
<td>Systolic BP (mmHg)</td>
<td>&lt;70</td>
<td>70–99</td>
<td>100–199</td>
<td>≥200</td>
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<tr>
<td>Body temperature (°C)</td>
<td>&lt;39</td>
<td>≥39</td>
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<tr>
<td>Only if VENT or CPAP: Paco₂ (mmHg)/FiO₂ (0.20)</td>
<td>&lt;100</td>
<td>100–199</td>
<td>≥200</td>
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<tr>
<td>Only if VENT or CPAP: Paco₂ (kPa)/FiO₂ (0.20)</td>
<td>&lt;13.3</td>
<td>13.3–26.6</td>
<td>≥26.6</td>
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<td>Urinary output (l/day)</td>
<td>&lt;0.50</td>
<td>0.50–0.999</td>
<td>≥1.000</td>
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<tr>
<td>Blood urea (mmol/l)</td>
<td>&lt;10.0</td>
<td>≥10.0</td>
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<tr>
<td>WBC (10³/mm³)</td>
<td>&lt;1.5</td>
<td>1.5–19.9</td>
<td>≥20.0</td>
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<tr>
<td>Serum K (mmol/l)</td>
<td>&lt;3.0</td>
<td>3.0–4.9</td>
<td>≥5.0</td>
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<tr>
<td>Serum Na (mmol/l)</td>
<td>&lt;125</td>
<td>125–144</td>
<td>≥145</td>
<td></td>
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<tr>
<td>Serum HCO₃ (mmol/l)</td>
<td>&lt;15</td>
<td>15–19</td>
<td>≥20</td>
<td></td>
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<tr>
<td>Bilirubin (μmol/l)</td>
<td>&lt;68.4</td>
<td>68.4–102.5</td>
<td>≥102.5</td>
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<tr>
<td>GCS</td>
<td>≤6</td>
<td>6–8</td>
<td>9–10</td>
<td>11–15</td>
<td>16–15</td>
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<tr>
<td>Chronic diseases</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Type of admission</td>
<td>Scheduled surgical</td>
<td>Medical</td>
<td>Unscheduled surgical</td>
<td>Met. can.</td>
<td>Hem. mal.</td>
<td>AIDS</td>
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</tbody>
</table>

**Fig. 1** SAPS II score sheet: BP, blood pressure; VENT, ventilated; CPAP, continuous positive airways pressure; WBC, white blood cells; GCS, Glasgow Coma Scale; Met. can., metastatic cancer; Hem. mal., hematological malignancy.
SAPS II

- Logit = $b_0 + b_1 \cdot \text{score} + b_2 \cdot [\ln(\text{score} + 1)]$
  - $b_0 = -7.7631$
  - $b_1 = 0.0737$
  - $b_2 = 0.9972$

- $\text{ROD} = e^{\text{logit}} / (1 + e^{\text{logit}})$
SAPS II scoring system

Score

Risk of Hospital Death
SAPS 3
SAPS 3
www.saps3.org

- October to December 2002
- 303 ICUs all over the world
- 16,784 patients
- ICU admission data (± 1 hour)
- ~80% for model development
- ~20% for model validation
SAPS 3

- 20 variables selected for the final model

50%

- Age
- Co-morbidities
- Use of vasoactive drugs before ICU admission
- Intrahospital location before ICU admission
- LOS in hospital before ICU admission
SAPS 3

22.5%

- Reasons for ICU admission
- Surgical status at ICU admission
- Planned/unplanned ICU admission
- Anatomical site of surgery
- Presence of infection at ICU admission & place acquired
SAPS 3

27.5%

- Lowest estimated GCS
- Highest heart rate
- Lowest systolic BP
- Highest bilirubin
- Highest body temp

- Highest creatinine
- Highest leucocytes
- Lowest platelets
- Lowest pH
- Ventilatory support & PaO2
### Table 1: SAPS 3 admission scoresheet—Part 1

<table>
<thead>
<tr>
<th>Box I</th>
<th>0</th>
<th>3</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>11</th>
<th>13</th>
<th>15</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>&lt;40</td>
<td>&gt;=40&lt;50</td>
<td>Cirrhosis, AIDS ³⁷</td>
<td>&gt;=60&lt;70</td>
<td>Cancer ⁵</td>
<td>&gt;=70&lt;75</td>
<td>&gt;=75&lt;80</td>
<td>&gt;=80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-Morbidities</td>
<td>Cancer therapy ²</td>
<td>Chorea, HF (NYHA IV), Hematological cancer ³⁶⁰</td>
<td>Cirrhosis, AIDS ³⁷</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Length of stay before ICU admission, days ¹</td>
<td>&lt;14</td>
<td>&gt;=14&lt;28</td>
<td>=28</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Intra-hospital location before ICU admission</td>
<td>Emergency room</td>
<td>Other ICU</td>
<td></td>
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<tr>
<td>Use of major therapeutic options before ICU admission</td>
<td>Vasoactive drugs</td>
<td>Other ⁶⁰</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Box II</th>
<th>0</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU admission: Planned or Unplanned Reason(s) for ICU admission</td>
<td>please see Part 2 of the scoresheet</td>
<td>Unplanned</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgical status at ICU admission</td>
<td>Scheduled surgery</td>
<td>No surgery ⁷</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anatomical site of surgery</td>
<td>Emergency surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute infection at ICU admission</td>
<td>Nosocomial ⁸</td>
<td>Respiratory ⁹</td>
<td></td>
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</tr>
</tbody>
</table>

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² Cancer therapy
³⁷ Cirrhosis, AIDS
³⁶⁰ Hematological cancer
⁷ No surgery
⁸ Nosocomial
⁹ Respiratory
Table 1 continued

<table>
<thead>
<tr>
<th>Box III</th>
<th>15</th>
<th>13</th>
<th>11</th>
<th>10</th>
<th>8</th>
<th>7</th>
<th>5</th>
<th>3</th>
<th>2</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>5</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Glasgow Coma Scale (lowest), points</td>
<td>3–4</td>
<td>5</td>
<td>6</td>
<td>7–12</td>
<td>&gt;=13</td>
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<tr>
<td>Total bilirubin (highest), mg/dL</td>
<td>&lt;=2</td>
<td>&gt;=2&lt;6</td>
<td>&gt;=6</td>
<td></td>
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<tr>
<td>Creatinine (highest), mg/dL</td>
<td>&lt;3.5</td>
<td>&gt;=2&lt;6</td>
<td>&gt;=6</td>
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<tr>
<td>Creatinine (highest), μmol/L</td>
<td>&lt;1.2</td>
<td>&gt;=2&lt;3.5</td>
<td>&gt;=3.5</td>
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<tr>
<td>Heart rate (highest), beats/minute</td>
<td>&lt;120</td>
<td>&gt;=120</td>
<td>&gt;=180</td>
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<tr>
<td>Leukocytes (highest), G/L</td>
<td>&lt;=7.25</td>
<td>&gt;=7.25</td>
<td>&gt;=15</td>
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<tr>
<td>Oxygenation (PaO2/FiO2)</td>
<td>PaO2/FiO2</td>
<td>PaO2/FiO2</td>
<td>PaO2/FiO2</td>
<td>PaO2/FiO2</td>
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<tr>
<td>Platelets (lowest), G/L</td>
<td>&lt;=20</td>
<td>&gt;=20&lt;50</td>
<td>&gt;=50&lt;100</td>
<td>&gt;=100</td>
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<tr>
<td>Systolic blood pressure (lowest), mm Hg</td>
<td>&lt;=40</td>
<td>&gt;=40&lt;70</td>
<td>&gt;=70&lt;120</td>
<td>&gt;=120</td>
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<tr>
<td>Hypoxia (lowest), mm Hg</td>
<td>&lt;=60</td>
<td>&gt;=60 and MV</td>
<td>no MV</td>
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</tbody>
</table>

The definition for all variables can be found in detail in Appendix C of the ESM. For names and abbreviations which are differing from those in the ESM, explanations are given below. Generally, it should be noted that no mutually exclusive conditions exist for the following fields: Comorbidities, Reasons for ICU admission, and Acute infection at ICU admission. Thus, if a patient has more than one condition listed for a specific variable, points are assigned for all applicable combinations.

1. This variable is calculated from the two data fields: ICU admission date and time—Hospital admission date and time (see Appendix C of the ESM).
3. If a patient has both conditions he/she gets double points.
4. Chronic HF (NYHA IV)/Haematological cancer refer both to the data definitions in Appendix C of the ESM: Co-Morbidities: Chronic heart failure class IV NYHA, Haematological cancer.
5. Cancer refers to the data definitions in Appendix C of the ESM: Co-Morbidities: Metastatic cancer.
6. Other refers to the data definitions in Appendix C of the ESM: Intra-hospital location before ICU admission: Ward, Other.
7. No surgery refers to the data definitions in Appendix C of the ESM: Surgical Status at ICU Admission: Patient not submitted to surgery.
8. Nosocomial refers to the data definitions in Appendix C of the ESM: Acute infection at ICU admission—Acquisition: Hospital-acquired.
9. Respiratory refers to the data definition in Appendix C of the ESM: Acute infection at ICU admission—Site: Lower respiratory tract: Pneumonia, Lung abscess, other.
10. PaO2, FiO2 refer to the data definitions in Appendix C of the ESM: Arterial oxygen partial pressure (lowest), Inspiratory oxygen concentration.
11. MV refers to the data definition in Appendix C of the ESM: Ventilatory support and mechanical ventilation.
<table>
<thead>
<tr>
<th>Reason(s) for ICU admission</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU admission</td>
<td>16</td>
</tr>
<tr>
<td><strong>Reason(s) for ICU admission</strong></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular: Rhythm disturbance</td>
<td>-5</td>
</tr>
<tr>
<td>Neurologic: Seizures</td>
<td>-4</td>
</tr>
<tr>
<td>Cardiovascular: Hypovolemic hemorrhagic shock, Hypovolemic non hemorrhagic shock. / Digestive: acute abdomen, Other</td>
<td>3</td>
</tr>
<tr>
<td>Neurologic: Coma, Stupor, Obtuned patient, Vigilance disturbances, Confusion, Agitation, Delirium</td>
<td>4</td>
</tr>
<tr>
<td>Cardiovascular: septic shock. / Cardiovascular: Anaphylactic shock, mixed and undefined shock</td>
<td>5</td>
</tr>
<tr>
<td>Hepatic: Liver failure</td>
<td>6</td>
</tr>
<tr>
<td>Neurologic: focal neurologic deficit</td>
<td>7</td>
</tr>
<tr>
<td>Digestive: severe pancreatitis</td>
<td>9</td>
</tr>
<tr>
<td>Neurologic: Intracranial mass effect</td>
<td>10</td>
</tr>
<tr>
<td>All others</td>
<td>0</td>
</tr>
</tbody>
</table>

(1) Every patient gets an offset of 16 points for being admitted (to avoid negative SAPS 3 Scores).

(2) If both reasons for admission are present, only the worse value (-4) is scored.
## Admission Scoresheet

<table>
<thead>
<tr>
<th>Anatomical site of surgery</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transplantation surgery: Liver, Kidney, Pancreas, Kidney and pancreas, Transplantation other</td>
<td>-11</td>
</tr>
<tr>
<td>Trauma – other, isolated: (includes Thorax, Abdomen, limb); Trauma – Multiple</td>
<td>-8</td>
</tr>
<tr>
<td>Cardiac surgery: CABG without valvular repair</td>
<td>-6</td>
</tr>
<tr>
<td>Neurosurgery: Cerebrovascular accident</td>
<td>5</td>
</tr>
<tr>
<td>All Other</td>
<td>0</td>
</tr>
</tbody>
</table>
SAPS 3

SAPS 3.xlsx
SAPS 3

- Total score 0 to 217

- Logit = -32.6659 + ln(SAPS 3 score + 20.5958) * 7.3068

- \[ P = \frac{e^{\text{logit}}}{1 + e^{\text{logit}}} \]
### SAPS 3

<table>
<thead>
<tr>
<th>Area</th>
<th>Equation</th>
<th>GOF $\hat{H}$</th>
<th>$p$</th>
<th>GOF $\hat{C}$</th>
<th>$p$</th>
<th>O/E</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australasia</td>
<td>Logit=$-22.5717 + \ln (\text{SAPS 3 score} + 1) \times 5.3163$</td>
<td>10.43</td>
<td>0.40</td>
<td>2.20</td>
<td>0.99</td>
<td>1.00</td>
<td>0.93-1.07</td>
</tr>
<tr>
<td>Central, South America</td>
<td>Logit=$-64.5990 + \ln (\text{SAPS 3 score} + 71.0599) \times 13.2322$</td>
<td>8.94</td>
<td>0.54</td>
<td>7.03</td>
<td>0.72</td>
<td>1.00</td>
<td>0.94-1.06</td>
</tr>
<tr>
<td>Central, Western Europe</td>
<td>Logit=$-36.0877 + \ln (\text{SAPS 3 score} + 22.2655) \times 7.9867$</td>
<td>15.13</td>
<td>0.13</td>
<td>12.15</td>
<td>0.27</td>
<td>1.00</td>
<td>0.94-1.06</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>Logit=$-60.1771 + \ln (\text{SAPS 3 score} + 51.4043) \times 12.6847$</td>
<td>10.13</td>
<td>0.43</td>
<td>7.12</td>
<td>0.71</td>
<td>1.00</td>
<td>0.92-1.08</td>
</tr>
<tr>
<td>North Europe</td>
<td>Logit=$-26.9065 + \ln (\text{SAPS 3 score} + 5.5077) \times 6.2746$</td>
<td>3.45</td>
<td>0.97</td>
<td>2.22</td>
<td>0.99</td>
<td>1.00</td>
<td>0.86-1.14</td>
</tr>
<tr>
<td>Southern Europe, Mediterranean countries</td>
<td>Logit=$-23.8501 + \ln (\text{SAPS 3 score} + 5.5708) \times 5.5709$</td>
<td>5.28</td>
<td>0.87</td>
<td>13.12</td>
<td>0.22</td>
<td>1.00</td>
<td>0.97-1.03</td>
</tr>
<tr>
<td>North America</td>
<td>Logit=$-18.8839 + \ln (\text{SAPS 3 score} + 1) \times 4.3979$</td>
<td>4.22</td>
<td>0.93</td>
<td>4.47</td>
<td>0.92</td>
<td>1.00</td>
<td>0.86-1.14</td>
</tr>
</tbody>
</table>

$\text{GOF} \hat{H}$: Hosmer-Lemeshow goodness-of-fit $\hat{H}$ test; $\text{GOF} \hat{C}$: Hosmer-Lemeshow goodness-of-fit $\hat{C}$ test; $p$: respective p-values; $O/E$: observed-to-expected mortality ratio; $CI$: 95% confidence interval.
SAPS 3

Risk of Hospital Death

- Overall
- North America
- Australasia
- Central, western Europe
- Southern Europe, Mediterranean countries
- North Europe
- Eastern Europe
- Central, South America

SAPS 3 score

Risk of Hospital Death

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

30 50 70 90 110 130 150

SAPS 3
SAPS 3

- Good discrimination
  - Area under ROC curve 0.848
- Good calibration
  - H-L
    - C = 14.29, p=0.16
    - H = 10.56, p=0.39
- SAPS 3
  - Can predict hospital mortality
Fig. 3  Hosmer-Lemeshow goodness-of-fit test Ĉ in the overall sample. Predicted risk of hospital death, observed hospital mortality rate, and the corresponding number of patients per decile are shown. Columns: Number of patients; squares: mean SAPS 3-predicted mortality per decile; circles: mean observed mortality per decile.
Fig. 4 Hosmer-Lemeshow goodness-of-fit test $\hat{H}$ in the overall sample. Predicted risk of hospital death, observed hospital mortality rate, and the corresponding number of patients per decile are shown. **Columns:** Number of patients; **squares:** mean SAPS 3-predicted mortality per decile; **circles:** mean observed mortality per decile.
Mortality Probability Model (MPM)
Mortality Probability Model (MPM)

- 1985 by Lemeshow et al.
- Entirely statistical derived
  - bottom up approach
  - 137 at admission & 75 at 24h reduced to
  - 7 at admission & 7 at 24h
- Coronary care, cardiac OT, burn and children <14 excluded
- Can collect values before admission & at 24h
- Variables more condition based
- Variables usually requiring ‘yes’ or ‘no’
MPM II
Lemeshow S et al, JAMA 1993, 270: 2478 - 2486

- 1993 Lemeshow et al.
- 2 datasets
  - ~ 6,000 patients in US hospitals
  - ~ 14,000 patients in Europe & North America
- $MPM_0$ & $MPM_{24}$
MPM_0

- 15 variables on admission identified

- Logit = b_0 + b_1x_1 + b_2x_2 + \ldots + b_{15}x_{15}

- ROD = \frac{e^{\text{logit}}}{(1 + e^{\text{logit}})}
MPM_{0}

- Coma or deep stupor 1.48592
- Heart rate 0.45603
- Systolic BP 1.06127
- Chronic renal insufficiency 0.91906
- Cirrhosis 1.13681
- Metastatic neoplasm 1.19979
- Acute renal failure 1.48210
MPM_0

- Cardiac dysrhythmia 0.28095
- Cerebrovascular incident 0.21338
- Gastrointestinal bleeding 0.39653
- Intracranial mass effect 0.86533
- Age (actual value) 0.03057
- CPR prior to admission 0.56995
- Mechanical ventilation 0.79105
- Non-elective surgery 1.19098
Admission variables

- Age 0.03268
- Cirrhosis 1.08745
- Intracranial mass effect 0.91314
- Metastatic neoplasm 1.16109
- Non-elective surgery 0.83404
Variables at 24h

- Coma or deep stupor: 1.68790
- Mechanical ventilation: 0.80845
- Creatinine: 0.72283
- Confirmed infection: 0.49742
- PaO2: 0.46677
- Prothrombin time: 0.55352
- Urine output: 0.82286
- Vasoactive drug therapy: 0.71628
MPM\textsubscript{48} and MPM\textsubscript{72}


- To develop model using data at 48h and 72h to predict hospital outcome
- 6,290 admissions in 6 ICUs of US
  - 3,023 completed 48h data
  - 2,233 completed 72h data
$\text{MPM}_{48}$ and $\text{MPM}_{72}$

- 13 variables were identified
  - Same as $\text{MPM}_{24}$ and
  - Same variable coefficients except
  - Different constant term, $b_0$
    - $\text{MPM}_{72} = -5.23840$
    - $\text{MPM}_{48} = -5.39153$
    - $(\text{MPM}_{24} = -5.64592)$
Sepsis related Organ Failure Assessment (SOFA) score
(SOFA) score

- JL Vincent et al
- Determine extent of organ failure &
- Rate of organ failure
- Six organs
  - Cardiovascular (MAP, vasopressor dosage)
  - Respiratory (PaO2/FiO2, IPPV)
  - Renal (creatinine, urine output)
  - Hepatic (bilirubin)
  - Coagulation (platelet)
  - Neurological (Glasgow coma scale)
Serial Evaluation of the SOFA Score to Predict Outcome in Critically Ill Patients
FL Ferreira etal JAMA. 2001;286:1754-1758

- Prospective, observational cohort study conducted from April 1 to July 31, 1999
- A 31-bed medicosurgical ICU at a university hospital in Belgium
- 352 consecutive patients (mean age, 59 years) admitted to the ICU for >24 hours for whom the SOFA score was calculated on admission and every 48 hours until discharge
- Initial SOFA score (0-24), Δ SOFA scores (differences between subsequent scores), and the highest and mean SOFA scores obtained during the ICU stay and their correlations with mortality.
Serial Evaluation of the SOFA Score to Predict Outcome in Critically Ill Patients

FL Ferreira et al. JAMA. 2001;286:1754-1758

- Initial, mean and highest scores correlate mortality (M)
- Initial & highest scores >11 or mean score >5 == M >80%
- For scores with 1st 48 hours,
  - If increased == M > 50% (independent on initial score)
  - If unchanged == M 27 to 35%
  - If decreased == M <27%
- If initial score <11, & dec. trend; M<6
- If initial score 2-7 & unch./inc. trend; M=37
- If initial score 8-11 & unch./inc. trend; M=60
- If initial score >11 & unch./inc. trend; M>90%
Multiple Organ Dysfunction (MOD) score
Multiple Organ Dysfunction (MOD) score

- JC Marshall et al

Six organs
- Cardiovascular (R/P = HRxCVP/MAP)
- Respiratory (PaO2/FiO2)
- Renal (creatinine)
- Hepatic (bilirubin)
- Coagulation (platelet)
- Neurological (Glasgow coma scale)
Logistic Organ Dysfunction System (LODS) score
Logistic Organ Dysfunction System (LODS) score

- Le Gall JR et al. *JAMA*. 1996;276:802-10
- Six organs
  - Cardiovascular (SBP, HR)
  - Respiratory (PaO2/FiO2)
  - Renal (urea, creatinine, urine output)
  - Hepatic (bilirubin)
  - Coagulation (platelet, prothrombin time)
  - Neurological (Glasgow coma scale)
Logistic Organ Dysfunction System (LODS) score

- Logit = -3.4043 + 0.4173*(LODS)

- Predicted Death Rate= \( \frac{e^{\text{Logit}}}{1 + e^{\text{Logit}}} \)
Scores for trauma
Scores for trauma

- Revised Trauma Score (RTS)
  - Glasgow Coma Scale
  - SBP
  - Respiratory rate
- Injury Severity Score (ISS)
- TRauma Injury Severity Score (TRISS)
  - CR Boyd J Trauma 1987;27:370-8
- A Severity Characterization Of Trauma (ASCOT)
  - HR Champion J Trauma 1990;30:539-45
- 24 h – ICU Trauma Score
  - MJ Vassar J Trauma 1992;32:490-500
Any scoring system indicating ICU workload?
Therapeutic intervention, nursing ICU scores

- Therapeutic Intervention Scoring System (TISS)
- TISS-28: simplified TISS
Questions & Comments