Roger C. Bone, MD, *Section Editor*

A New Simplified Acute Physiology Score (SAPS II) Based on a European/North American Multicenter Study

Jean-Roger Le Gall, MD; Stanley Lemeshow, PhD; Fabienne Saulnier, MD

Objective.—To develop and validate a new Simplified Acute Physiology Score, the SAPS II, from a large sample of surgical and medical patients, and to provide a method to convert the score to a probability of hospital mortality.

Design and Setting.—The SAPS II and the probability of hospital mortality were developed and validated using data from consecutive admissions to 137 adult medical and/or surgical intensive care units in 12 countries.

Patients.—The 13 152 patients were randomly divided into developmental (65%) and validation (35%) samples. Patients younger than 18 years, burn patients, coronary care patients, and cardiac surgery patients were excluded.

Outcome Measure.—Vital status at hospital discharge.

Results.—The SAPS II includes only 17 variables: 12 physiology variables, age, type of admission (scheduled surgical, unscheduled surgical, or medical), and three underlying disease variables (acquired immunodeficiency syndrome, metastatic cancer, and hematologic malignancy). Goodness-of-fit tests indicated that the model performed well in the developmental sample and validated well in an independent sample of patients (P=.883 and P=.104 in the developmental and validation samples, respectively). The area under the receiver operating characteristic curve was 0.88 in the developmental sample and 0.86 in the validation sample.

Conclusion.—The SAPS II, based on a large international sample of patients, provides an estimate of the risk of death without having to specify a primary diagnosis. This is a starting point for future evaluation of the efficiency of intensive care units.

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SINCE 1981, several severity scores have been proposed for intensive care unit patients. The first ones (Acute Physiology and Chronic Health Evaluation, referred to as APACHE,[1] APACHE II,[2] and Simplified Acute Physiology Score, referred to as SAPS[3]) were built by a subjective method, using a panel of experts to select variables and weights. More recent systems (Mortality Probability Model, referred to as MPM,[4-6] and APACHE III[7]) use statistical modeling techniques to select and weight the variables, and risk of death is estimated through the use of a multiple logistic regression model.

The European/North American study we describe in this article was undertaken to propose a new Simplified Acute Physiology Score, the SAPS II, from a large sample of medical and surgical patients, and to develop a method for converting the score to a probability of hospital mortality. Logistic regression analysis was used to assist in (1) selecting the variables that would constitute SAPS II, (2) deciding on appropriate groupings and point assignments for each variable, and (3) converting the SAPS II score to a probability of hospital mortality.

MATERIALS AND METHODS

This study involved 137 medical, surgical, or mixed ICUs in 12 countries, and took place from September 30, 1991, through February 28, 1992. Enrollment of patients into the study took place from September 30 through December 27, 1991. Patients were followed up in the hospital for the next 2 months; any patients remaining in the hospital on February 28, 1992, were dropped from the study. All consecutive admissions, 18 years of age or older, to the adult ICUs

From the Faculty of Medicine Lariboisière-Saint-Louis, Paris, France (Dr Le Gall); the School of Public Health, University of Massachusetts, Amherst (Dr Lemeshow); and The Evaluation Center of Lille (France) (Dr Saulnier).

A complete list of study participants appears at the end of this article.

Reprint requests to Service de Réanimation Médicale, Hôpital Saint-Louis, 1 avenue Claude Vellefaux, Paris, France 75010 (Dr Le Gall).

Table 1.—Number of Intensive Care Unit (ICU) Patients, Mortality Rate, Age, Sex, Type of Admission, and Length of Stay in ICU and Hospital, by Country

Country	ICU Patients, No.	Mortality Rate, %	Age, y		Sex, %		Type of Admission, %			Length of Stay, d			
							Surgical			In ICU		In Hospital*	
			Mean	SD	Male	Female	Unscheduled	Scheduled	Medical	Mean	SD	Mean	SD
Belgium	1091	21.7	57.5	18.2	62.1	37.9	15.2	33.5	42.8	6.2	9.8	21.5	21.7
Finland	720	17.6	56.3	17.4	59.0	41.0	25.8	28.2	46.0	4.1	5.5	14.0	13.7
France	1393	28.9	56.9	19.1	61.5	38.5	12.0	8.8	79.3	9.7	12.4	18.9	20.2
Germany/Austria	1807	15.7	56.6	18.2	58.6	41.4	28.1	50.9	21.1	6.0	8.7	21.0	18.5
Italy	1297	31.3	58.1	18.3	62.6	37.4	23.2	33.2	43.6	7.2	10.2	20.5	19.3
Spain	1270	27.1	54.9	18.3	62.9	37.0	18.3	26.1	55.2	9.5	12.2	22.8	21.2
Switzerland	756	13.8	54.9	18.7	62.2	37.8	15.5	21.7	62.8	4.9	5.6	17.6	17.1
The Netherlands	950	20.0	60.3	17.1	63.3	36.7	25.4	45.8	28.7	5.5	8.3	19.3	15.9
United Kingdom	136	32.4	57.4	18.7	61.8	38.2	27.9	24.3	47.8	5.7	7.1	14.8	15.9
United States/Canada	3732	19.7	57.9	19.0	55.1	44.9	16.9	29.5	53.5	5.9	8.4	17.1	18.2
Total	**13 152**	21.8	57.2	18.5	59.6	40.4	19.6	31.2	48.4	6.6	9.5	19.1	18.9

*Number of days in hospital from beginning of ICU stay.

in participating hospitals were eligible for enrollment, but burn patients, coronary care patients, and cardiac surgery patients were excluded from the statistical analyses presented in this article.

A comprehensive operations manual, describing study procedures, data collection requirements, and variable definitions, was provided to each participating institution. Any procedural or definitional questions from data-collection personnel in the ICUs were referred to the administrative or statistical coordinators, as appropriate. Data were collected on forms and then entered into a computer program specifically designed for this study. The program, available in both IBM and Macintosh formats, contained out-of-range and logical-error checking. Interrater quality control was performed by having each site coordinator complete a second set of forms for a 5% random sample of that ICU's study patients. For each ICU, the original and duplicate variables were compared to determine whether there was an acceptable rate of agreement between the first and second data-collection effort. The κ statistics[8] and intraclass correlation coefficients[9] were used to assess the quality of the data.

Data collection included patient demographic information, all variables necessary for computing the original SAPS, a set of new variables that might possibly become part of the SAPS II, and vital status at hospital discharge. The set of new variables was chosen for clinical reasons by the team of country coordinators before the study started. The physiology variables were recorded by the data collectors as the worst value in the first 24-hour period in the ICU. The worst value was defined as the value that would have been assigned the greatest number of SAPS points in the original SAPS score.

To develop the SAPS II, 65% of the available patients were randomly selected to constitute the developmental data set, while the remaining 35% became the validation data set. Each of the possible explanatory variables was independently evaluated for its association with hospital mortality. These bivariate analyses were used to screen through the set of independent variables to identify a smaller subset associated with hospital mortality. Each statistically significant continuous variable was then plotted against vital status at hospital discharge and the LOWESS (locally weighted least squares) smoothing function[10] was used to suggest ranges for each variable. The LOWESS technique is a method for producing smoothed values of y for values of x. The method, which is computationally intense for large data sets, generates a predicted value of y for values of x, and the plot of this smoothed function can be examined to identify cut points along the x values that are associated with changes in the predicted y values.

To assign points to ranges, dummy variables were created for each range, and all such dummy variables were used in a multiple logistic regression analysis. The resulting coefficients of this analysis were used to assign points to ranges. The general rule was to multiply the β for each range by 10 and round off to the nearest integer. Once the SAPS II score was calculated for each patient, it was used in a multiple logistic regression equation designed to convert this score to a probability of hospital mortality.

To assess the performance of the system, formal goodness-of-fit (Hosmer-Lemeshow[11]) tests were performed on both the developmental and validation sets to evaluate calibration. The Hosmer-Lemeshow technique is based on the calculation of the expected mortality in groups formed using equal probability intervals, which can then be compared with the observed mortality. Within each decile the expected number of deaths is computed by summing the probability of mortality for each patient in that decile. To evaluate the fit of the model, the expected outcomes within each decile of the population are compared with the observed outcomes for each decile. These values for all cells of the table are summed to form the test statistic, $\hat{H}$, which is compared with the χ^2 distribution (df=8) to evaluate the overall fit of the model to the data. If one is assessing fit in the same sample as that on which the model was generated, the df is equal to the number of groups (g) minus 2. When an external model is applied to a new set of data, as is the case in the validation of the model, the df is equal to g. A small value of $\hat{H}$ and the corresponding high P value would suggest good fit, while a large value of $\hat{H}$ and the corresponding low P value would indicate lack of fit. Area under the receiver operating characteristic (ROC) curve[12] was used in the two data sets to evaluate discrimination.

The SAPS II was compared with the old SAPS for each patient in the validation sample. This sample was selected since these patients were not used in the development of SAPS II. The area under the ROC curve was computed for the old SAPS and SAPS II and the correlation between the two scores was computed.

RESULTS

Of the 14 745 enrolled patients, 1593 were excluded (burn patients, coronary patients, and cardiac surgery patients), leaving 13 152 for model development and validation. Table 1 presents, for each country, the number of patients, hospital mortality rate by country, sex, type of admission, and length of stay in ICU and hospital. The mortality rates varied from 13.8% in Switzerland to 32.4% in the United Kingdom, but it is important

to note that these are crude mortality rates. The ICUs were not randomly selected and should not be assumed to be representative of all ICUs in any given country. In all of the countries, there were more male than female patients.

Of the 37 variables collected to build the SAPS II, only 17 were included in the final SAPS II score. Patients who were missing information on type of admission (scheduled surgical, unscheduled surgical, or medical) could not be included in the final analysis since they could not be correctly categorized for the assignment of points. Similarly, patients missing ventilation information for whom the PaO_2/fraction of inspired oxygen (FIO_2) ratio could not be calculated were excluded. These exclusions removed 155 cases from the database, so the final SAPS II was developed from and validated on 12 997 patients, 8369 in the developmental sample and 4628 in the validation sample. Variables were excluded if they were unrelated to hospital mortality in the bivariate analyses or were not necessary once other variables were included in the multivariate model. Table 2 presents the variables that were collected but not included in the SAPS II score.

Table 3 presents the variables, ranges, and points that make up the SAPS II system. The SAPS II score is made up of 17 variables: 12 physiological variables, age, type of admission (scheduled surgical, unscheduled surgical, or medical), and three variables related to underlying disease: acquired immunodeficiency syndrome, metastatic cancer, and hematologic malignancy. Table 4 presents the definitions of the variables constituting the SAPS II system.

The results of the data quality analyses confirmed that the variables in the SAPS II system demonstrated good reliability. The intraclass correlation for serum potassium was 0.81, and for systolic blood pressure and body temperature the intraclass correlations were greater than 0.87. For heart rate, serum sodium level, Glasgow Coma Score, FIO_2, PaO_2, and bilirubin level, the intraclass correlations were greater than 0.90, and they were greater than 0.95 for age, urinary output, serum urea nitrogen level, white blood cell count, and serum bicarbonate level. The κ values for the categorical variables were as follows: 0.67 for hematologic malignancy (99.7% agreement), 0.89 for metastatic cancer (98.8% agreement), 0.97 for type of admission (97.8% agreement), and 1.00 for acquired immunodeficiency syndrome (100% agreement).

Points assigned for each variable vary from 0 to 3 (for temperature) up to 0 to 26 (for Glasgow Coma Score). For the 12 physiological variables, the worst value during the first 24 hours in the ICU is taken into account. No arterial sample is necessary if the patient is not ventilated or receiving continuous positive airway pressure. For sedated patients, the Glasgow Coma Score before sedation was used. This was ascertained either from interviewing the physician who ordered the sedation, or by reviewing the patient's medical record.

From the developmental set of 8369 patients, an equation, based on the multiple logistic regression model, was developed for converting the SAPS II score to a probability of hospital mortality. Since it was observed that the distribution of the SAPS II score was highly skewed, a shrinking power transformation,[13] ln(SAPS II score+1), where *ln* indicates the natural logarithm, was incorporated into the model. Thus, the model contained two explanatory variables, SAPS II score and ln(SAPS II score+1).

The first step to calculate a probability of hospital mortality is to compute the logit, as follows:

$$\text{logit}=\beta_0+\beta_1(\text{SAPS II score})+\beta_2[\ln(\text{SAPS II score}+1)]=-7.7631+0.0737(\text{SAPS II score})+0.9971[\ln(\text{SAPS II score}+1)].$$

This logit is converted to a probability of hospital mortality with the following equation:

$$\Pr(y=1/\text{logit})=e^{\text{logit}}/1+e^{\text{logit}},$$

where Pr indicates probability, and e indicates a mathematical constant 2.7182818, which represents the base of the natural logarithm.

Table 5 presents the goodness-of-fit test performed on the developmental data set. The P value for this test was .883. Since this P value is large (considerably greater than .05), the model very closely reflects the true mortality experience in the developmental data set. In the validation data set, the P value for the goodness-of-fit test was .104, suggesting that the model reflected the mortality experience in a group of patients independent of those on whom the model was developed.

The areas under the ROC curve for the SAPS II were 0.88 (95% confidence interval, 0.87 to 0.90) in the developmental data set and 0.86 (95% confidence interval, 0.84 to 0.88) in the validation data set. Areas this large are generally acknowledged to constitute excellent discrimination.

The old SAPS (14 variables) was computed for each patient in the validation data set. Results suggest that the SAPS II (17 variables) offers a significant improvement in all respects. The area under the ROC curve was 0.80 for the old SAPS, while it was 0.86 for SAPS II. Furthermore, the correlation coefficient between the old and new SAPS was 0.79, suggesting that only 62% of the variability in SAPS II could be explained by the old SAPS. This suggests that the SAPS II represents a significant improvement over the original SAPS system.

Table 2.—Nonsignificant Variables*

Acute physiology
Respiratory rate
Serum glucose level
Serum albumin level
Serum creatinine level
Organ system failure first day
Respiratory failure
Cardiovascular failure
Renal failure
Hematologic failure
Neurological failure
Hepatic failure
Comorbid conditions
Cirrhosis
Insulin-dependent diabetes
Chronic obstructive pulmonary disease
Heart failure
Taking nonsteroidal anti-inflammatory drugs
Receiving chemotherapy
Taking steroids
Previous health status
ABCD System (four possibilities)
MacCabe (three classes)

*These variables either were nonsignificant by the univariate analysis or did not improve the goodness-of-fit in the logistic regression equation.

COMMENT

The SAPS II has been built from a European/North American study involving patients from medical, surgical, and mixed ICUs in 10 European and two North American countries. Burn and cardiac patients were excluded. Burn patients are often treated in units other than general ICUs, and specific prognostic systems have been developed for them. While cardiac patients (coronary and cardiac surgery) have been excluded from the development and validation of the SAPS II (as they were from all of the other scoring systems for ICU patients), there is some suggestion that the systems may perform well for these patients.[14] Before it can be suggested that any of the systems can provide accurate estimates of the probability of hospital mortality for these patients, extensive studies must be performed and models should be adjusted when necessary.

The selection of variables and the weights assigned to levels of these variables in the SAPS II was accomplished with the assistance of the logistic regression modeling technique.[4-6] This approach differs from the one used in the older systems,[2,3] in which clinical judgment alone was used.

Examination of the eliminated variables (Table 2) is of some interest. While each of these variables may be important in a univariate sense, they are not

Table 3.—SAPS II Scoring Sheet*

Variable Points:	26	13	12	11	9	7	6	5	4	3	2	0
Age, y												<40
Heart rate, beats/min				<40							40-69	70-119
Systolic BP, mm Hg		<70						70-99				100-199
Body temperature, °C (°F)												<39° (<102.2°)
Only if ventilated or continuous pulmonary artery pressure PaO_2, mm Hg/FiO_2				<100	100-199		≥200					
PaO_2, kPa/FiO_2				<13.3	13.3-26.5		≥26.6					
Urinary output, L/d				<0.500					0.500-0.999			≥1.000
Serum urea level, mmol/L (g/L) or serum urea nitrogen level, mg/dL												<10.0 (<0.60) <28
WBC count (10^3/cu mm)			<1.0									1.0-19.9
Serum potassium, mmol/d										<3.0		3.0-4.9
Serum sodium level, mmol/L								<125				125-144
Serum bicarbonate level, mEq/L							<15			15-19		≥20
Bilirubin level, μmol/L (mg/dL)												<68.4 (<4.0)
Glasgow Coma Score	<6	6-8				9-10		11-13				14-15
Chronic diseases												
Type of admission												Scheduled surgical
Sum of points												

*SAPS indicates Simplified Acute Physiology Score; BP blood pressure; FiO_2, fraction of inspired oxygen; kPa, kilopascal; WBC, white blood cell; and AIDS, acquired immunodeficiency syndrome.

needed as components of the SAPS II score once the other variables are included. For some variables explanations can be proposed. For instance, organ-system failures are taken into account by the other physiological variables; immunosuppressive therapy could be accounted for by the selected chronic diseases; the effect of severe cirrhosis may be taken into account by high bilirubin levels.

Collecting the data necessary to calculate the SAPS II score is very simple and quick. We estimate that it would take less than 5 minutes per patient. All the variables in the SAPS II are readily available and require neither special venous nor arterial blood samples.

One of the goals of the modeling process was to maintain a pure physiology-based system. However, criteria of calibration and discrimination were improved considerably by including the three underlying chronic clinical conditions. As with any system based on clinical measurements, missing values present a problem that has been outlined by others.[15] This problem is generally solved by assuming that values not recorded in the medical record are within normal limits. These same rules were followed with SAPS II since, for instance, in some countries serum bilirubin level is not systematically measured. Similarly, blood gases are not typically measured in all nonventilated patients.

Some systems require that a single diagnosis be specified for estimating the probability of mortality. For SAPS II the probability of mortality is calculated directly from the score using a logistic regression equation, without adding points or any sort of correction for diagnosis. This decision was made before the study began, on the assumption that selection of a single diagnosis is too difficult for most ICU patients.[16] While some patients can be categorized according to a specific, simple, and unique diagnosis, such as chronic obstructive pulmonary disease, septic shock, or barbiturate overdose, this is not the case in general. In fact, for the patients in that study,[16] it was possible to categorize only 37% of patients into only one diagnostic category, with remaining patients having multiple diagnoses. While knowledge of diagnosis would certainly have an impact on the estimated probability of mortality, such estimates would be available on a small percentage of ICU patients. When ICU patients do have several diagnoses, it is often problematic to select the most important one. For example, if a patient has adult respiratory distress syndrome and associated purulent peritonitis, which is the main diagnosis? Other systems do require that principal diagnosis be specified and, as a result, risk of death will differ according to the chosen category. Before it can be determined that adjustment for diagnosis has been successful in estimating risk, the calibration of the model must be carefully checked within diagnosis groups.

The goodness-of-fit of SAPS II for this population of patients studied in 1991 through 1992 suggests that the probabilities of mortality reflect the true mortality experience in the data. It is imperative that the goodness-of-fit continue to be evaluated in the future in other populations of patients. The performance of SAPS II demonstrates that it is an extremely effective system for estimating the probability of mortality for ICU patients. Future research should be directed at comparing the performance among common cohorts of patients using all available systems. Establishing and maintaining a database of ICU patients from all over the world is an important objective for the future to assure that the SAPS II will remain modern and evolve in an appropriate way.

While no severity score is perfect in predicting mortality, the SAPS II performed very well over the whole range of participating ICUs. The SAPS II score is the easiest of all the ICU severity systems to use for obtaining probabilities of hospital mortality. This ease of

1	2	3	4	6	7	8	9	10	12	15	16	17	18
					40-59				60-69	70-74	75-79		≥80
			120-159		≥160								
	≥200												
		≥39° (≥102.2°)											
				10.0-29.9 (6.0-1.79) 28-83				≥30.0 (≥1.80) ≥84					
		≥20.0											
		≥5.0											
≥145													
			68.4-102.5 (4.0-5.9)				≥102.6 (≥6.0)						
							Metastatic cancer	Hematologic malignancy				AIDS	
				Medical		Unscheduled surgical							
							Total SAPS II Score		=				**Points**
							Risk of Hospital Death		=				**%**

use, coupled with the fact that the algorithm for computing probabilities of hospital mortality is in the public domain, should result in its widespread acceptance. It must be emphasized that, as is the case for all severity systems for ICU patients, it is most appropriate to interpret probabilities resulting from SAPS II in the aggregate. Application to individual patients is far more difficult because the models have been developed from a large and heterogeneous (with respect to diagnosis) database and the probability may be thought of as the probability for an "average" patient.

The goodness-of-fit tests assure us that the models are calibrated correctly, on average, to the wide range of diagnoses and skills represented in our database. If the models do not fit in particular ICUs, the implications must be considered with great care. First, it could mean that the care provided in that ICU is above or below average. But poor calibration can also be the result of an unusual mix of patients—a mix that is not well represented in the database on which the model was developed. The fact that the SAPS II calibrates well, as evidenced by the correspondence of observed and expected numbers of deaths over deciles of risk in both the developmental and validation samples, suggests that this is a tool that does reflect the average ICU patient in the average

Table 4.—Variables and Definitions for SAPS II*

Variable	Definition
Age	Use the patient's age (in years) at last birthday
Heart rate	Use the worst value in 24 hours, either low or high heart rate; if it varied from cardiac arrest (11 points) to extreme tachycardia (7 points), assign 11 points
Systolic blood pressure	Use the same method as for heart rate: eg, if it varied from 60 mm Hg to 205 mm Hg, assign 13 points
Body temperature	Use the highest temperature in degrees Centigrade or Fahrenheit
PaO_2/FIO_2 ratio	If ventilated or continuous pulmonary artery pressure, use the lowest value of the ratio
Urinary output	If the patient is in the intensive care unit for less than 24 hours, make the calculation for 24 hours: eg, 1 L in 8 hours = 3 L in 24 hours
Serum urea or serum urea nitrogen level	Use the highest value in mmol/L or g/L for serum urea, in mg/dL for serum urea nitrogen
WBC count	Use the worst (high or low) WBC count according to the scoring sheet
Serum potassium level	Use the worst (high or low) value in mmol/L, according to the scoring sheet
Serum sodium level	Use the worst (high or low) value in mmol/L, according to the scoring sheet
Serum bicarbonate level	Use the lowest value in mEq/L
Bilirubin level	Use the highest value in μmol/L or mg/dL
Glasgow Coma Score	Use the lowest value; if the patient is sedated, record the estimated Glasgow Coma Score before sedation
Type of admission	Unscheduled surgical,† scheduled surgical,‡ or medical§
AIDS	Yes, if HIV-positive with clinical complications such as *Pneumocystis carinii* pneumonia, Kaposi's sarcoma, lymphoma, tuberculosis, or toxoplasma infection
Hematologic malignancy	Yes, if lymphoma, acute leukemia, or multiple myeloma
Metastatic cancer	Yes, if proven metastasis by surgery, computed tomographic scan, or any other method

*SAPS indicates Simplified Acute Physiology Score; FIO_2, fraction of inspired oxygen; WBC, white blood cell; AIDS, acquired immunodeficiency syndrome; and HIV, human immunodeficiency virus.
†Patients added to operating room schedule within 24 hours of the operation.
‡Patient whose surgery was scheduled at least 24 hours in advance.
§Patients having no surgery within 1 week of admission to intensive care unit.

Table 5.—Goodness-of-Fit Test for the SAPS II in the Developmental Sample of 8369 Patients*

Probability of Dying	Survived, No.		Died, No.	
	Observed (n=6533)	Expected	Observed (n=1836)	Expected
.00-.10	4066	4060.4	165	170.7
>.10-.20	1164	1174.0	211	201.0
>.20-.30	451	442.6	137	145.4
>.30-.40	332	338.3	184	177.7
>.40-.50	194	187.8	145	151.2
>.50-.60	144	146.2	182	179.8
>.60-.70	73	71.3	131	132.7
>.70-.80	68	67.0	198	199.0
>.80-.90	26	31.7	191	185.3
>.90->.99	15	13.7	292	293.3

*SAPS indicates Simplified Acute Physiology Score. $\hat{H}$=3.70; *df*=8; *P*=.883. See "Materials and Methods" for a description of $\hat{H}$.

ICU. Interpretations for specific groups of patients must be handled with considerably greater caution.

The comparison with the old SAPS, widely used in France and some other European countries, suggests that although most of the variables are the same, significant modifications have been made. The SAPS II resulted in a significantly higher area under the ROC curve than was obtained with the original SAPS.

What use could be made of knowing the probability of mortality for patients after 24 hours in a given ICU? First, we must remember that probabilities make sense only when used as an aggregate measure of risk; second, probabilities cannot say exactly which individuals will die in the hospital, only that a percentage of patients with the same probability are likely to die. The value of the SAPS II score and probability is not primarily to estimate the risk of death for a particular patient. This would be interesting only in theory, since the observed outcome for an individual patient can only be 0 (survived) or 1 (died). While it might be valuable for a family to know that the estimated probability of mortality is 0.37 as opposed to 0.48, it would rarely be appropriate to use such information to influence treatment decisions.

The risk of death may be useful in carefully predefined, precise diagnostic subgroups to compare two randomly selected groups for significant differences. For this purpose a score was used in most of the studies appearing in the literature.[17,18] It seems more logical to assess the comparability of two randomized groups with respect to probability of mortality. Indeed, since different scoring systems may be used, reporting probability of mortality would be a common denominator.

The SAPS II probability of mortality is a starting point for future evaluation of efficiency of ICUs, but its comparison with an observed death rate remains to be interpreted. As for other studies with other scores,[19,20] the discrepancies may be due to patient-mix differences, hospital factors, admission and discharge policies, quality of care, and quality of data collection.

Future studies should follow two directions. The first direction is to continue to collect data in order to maintain the excellence of the SAPS II score. The qualities of the model must be periodically checked. As time passes, the types of patients treated in ICUs may change, as well as the therapies used by ICU physicians. The second direction is to collect the variables on a daily basis and to study the daily probability of mortality. This has been done by other researchers.[21] Whereas collecting the SAPS II on a daily basis might be too time-consuming for most ICUs, a second look after a few days would be the most efficient way to evaluate the progression of risk of death.

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Study participants included the following: **Overall Study Coordinators:** J.-R. Le Gall, Hôpital Saint-Louis, Paris, France; S. Lemeshow, University of Massachusetts, Amherst; **Austria:** *Country Coordinator:* H. Burchardi; *University Hospital, Innsbruck:* H. Benzer, C. Huber; **Belgium:** *Country Coordinator:* J. P. Alexander; *Algemeen Ziekenhuis Middelheim, Antwerpen:* J. P. Alexander, M. Delande; *Centre Hospitalier Universitaire de Liège, Liège:* D. Ledoux, J. L. Canivet, P. Damas; *Algemeen Ziekenhuis Stuivenberg, Antwerpen:* I. Demeyer, K. Vissers; *Clinique Saint Pierre, Ottignies:* Th. Dugernier; *Academisch Ziekenhuis Vrije Universiteit Brussel, Brussel:* L. Huyghens, M. Diltour, N. De Wit; *Algemeen Ziekenhuis Middelheim, Antwerpen:* J. Nagler, F. Cools; *Onze Lieve Vrouw Ziekenhuis, Aalst:* G. Nollet, J. Verbeke; *Universitair Ziekenhuis Gent, Gent:* J. Poelaert, F. Collardyn; *Clinique Universitaire Saint Luc, Bruxelles:* P. F. Laterre, A. Dougnac, M. Reynaert; *Sint Vincentius Ziekenhuis, Antwerpen:* R. Rutsaert, L. Colemont; *Universitair Ziekenhuis Gasthuisberg, Leuven:* M. Schetz, P. Lauwers; **Canada:** *Country Coordinator:* D. Teres; *University of Alberta Hospitals, Edmonton:* S. Hamilton, C. Norris; *Royal Alexandra Hospital, Edmonton:* A. Shustack, R. Johnston, E. Konopad; **Finland:** *Country Coordinator:* A. Kari; *Central Hospital of North Karelia, Joensuu:* P. Hannonen; *Central Hospital of Central Finland, Jyväskylä:* K. Hersio; *Vaasa Central Hospital, Vaasa:* P. Kairi; *Kuopio University Hospital, Kuopio:* A. Kari, M. Niskanen; *Turku University Central Hospital, Turku:* J. Klossner; *Oulu University Central Hospital, Oulu:* E. Saarela; *Central Hospital of Southern Saimaa, Lappeenranta:* M. Vähämurto; **France:** *Country Coordinator:* F. Saulnier; *Centre Hospitalier Regional de Nimes, Nimes:* C. Arice; *Centre Hospitalier d'Annonay, Annonay:* B. Bedocq; *Hôpital General, Dijon:* B. Blettery; *Hôpital Saint Joseph, Paris:* B. Misset, J. Carlet; *Hôpital Louis Mourier, Colombes:* L. Mier, D. Dreyfuss; *Hôpital Avicenne, Bobigny:* J. P. Fosse; *Centre Hospitalier Morvan, Brest:* B. Garo; *Centre Hospitalier de Bourg en Bresse, Bourg en Bresse:* G. Demingeon, L. Holzapfel; *Pavillon Pasteur–Centre Hospitalo Universitaire, Strasbourg:* J. Kopferschmitt; *Centre Hospitalo Universitaire Saint Etienne Nord, Saint Priest en Jarez:* P. Mahul; *Institut Gustave-Roussy, Villejuif:* G. Nitenberg; *Centre Hospitalier d'Agen, Agen:* F. Plouvier; *Hôpital Albert Calmette, Lille:* F. Saulnier; *Centre Hospitalo Universitaire–Hôtel Dieu, Nantes:* D. Villers; **Germany:** *Country Coordinator:* H. Burchardi; *University Hospital, Ulm:* H. Wiedeck; *University Hospital, Göttingen:* H. Burchardi, H. Klingler; *University Hospital, Mainz:* W. Dick, F. Brost; *Zentralklinikum, Augsburg:* J. Eckart, P. Wengert; *University Hospital, Freiburg/Breisgau:* K. Geiger, K. Armbruster; *Zentralkrankenhaus Sankt Jürgenstrasse, Bremen:* H.-D. Kamp, M. Rothe; *Städtisches Krankenhaus München-Bogenhausen, München:* B. Landauer, T.-O. Schmid; *University Hospital, München:* K. Peter, H. Forst; *Klinikum der Landeshaupstadt, Wiesbaden:* C. Piper; *University Hospital Steglitz, Berlin:* K. Reinhart, T. Rudolph; *University Nürnberg-Erlangen, Erlangen:* E. Rügheimer, E. Pscheidl; *Klinikum der Landeshaupstadt, Wiesbaden:* J. Schmitz; *Städtisches Krankenhaus, Hildesheim:* H.-P. Schuster, K.F. Bodmann; *Klinikum Friedrichshain, Berlin:* D. Stober, C. Dressler; **Italy:** *Country Coordinator:* G. Iapichino; *Ospedale Maggiore, Milano:* G. Iapichino, S. Rotelli; *Ospedale Niguarda Cà Granda, Milano:* A. Ravizza, G. Casella; *Ospedale San Carlo Borromeo, Milano:* D. Ripamonti, A. Favero; *Ospedale San Paolo, Milano:* S. Vesconi, A. Sicignano; *Ospedale San Raffaele, Milano:* D. Giudici, G. Gallioli; *Ospedale Civile, Melegnano:* A. Guarino, G. Merli; *Ospedale San Gerardo, Monza:* R. Fumagalli, L. Avalli; *Ospedale Civile, Vimercate:* F. Bassi, B. M. Graziani; *Policlinico San Matteo, Pavia, I:* F. Albertario, L. Carnevale; *Policlinico San Matteo, Pavia, II:* F. Bobbio Pallavicini, C. Cassini; *Ospedale Regionale, Aosta:* S. Vernero, A. Viale; *Ospedale Maggiore, Bologna:* M. T. Fiandri, D. Cosco; *Policlinico Sant' Orsola, Bologna:* R. Melotti, G. Negro; *Arcispedale Sant' Anna, Ferrara:* M. Capuzzo, C. A. Volta; *Ospedale Maggiore, Parma:* M. Mergoni, A. Saccani; *Ospedale Santa Maria Battuti, Treviso:* G. Simini, A. Manuali; *Ospedale San Bortolo, Vicenza:* L. Lacquaniti, T. Moretti; *Ospedale di Cattinara, Trieste:* L. Serra, S. Fasiolo; *Policlinico Umberto I, Roma:* G. Conti, A. de Blasi; *Policlinico, Bari:* G. Cinnella, A. Brienza; **Netherlands:** *Country Coordinator:* D. Reis Miranda; *Academisch Ziekenhuis, Rotterdam:* H. A. Bruining; *Ziekenhuis Leijenburg, Den Haag:* J. de Haas; *Academisch Ziekenhuis Vrije Universiteit, Amsterdam:* D. de Jong; *Medisch Centrum Alkmaar, Alkmaar:* M. de Jong; *Scheperziekenhuis, Emmen:*

W. P. Haanstra; *Academisch Ziekenhuis, Utrecht:* P. F. Hulstaert; *Zuiderziekenhuis, Rotterdam:* R. Jairam; *Academisch Ziekenhuis, Nijmegen:* R. van Dalen; *Academisch Ziekenhuis, Maastricht:* S. van der Geest; *Twenteborgziekenhuis, Almelo:* A. J. J. Woittiez; *Academisch Ziekenhuis, Groningen:* J. H. Zwaveling; **Spain:** *Country Coordinator:* A. Artigas; *Hospital Son Dureta, Palma Mallorca:* R. Abizanda, B. Balerdí, Ll. Socías; *Hospital de Sabadell, Sabadell:* A. Artigas, J. Mestre, X. Castella; *Hospital Josep Trueta, Girona:* A. Bonet, A. Alvarez; *Hospital de la Vall d'Hebró, Barcelona:* J.L. Bóveda, I. Manzanares, I. Salgado, S. Gutierrez; *Hospital de Barcelona, Barcelona:* L. Cabré, G. Carrasco, R. Molina; *Hospital Comarcal d'Igualada, Igualada:* M. Casanovas, E. Faraidun, J. M. Bausili; *Hospital de la Creu Roja d'Hospitalet, Hospitalet de Llobregat:* M. Cerdà, M. Ibars, C. Gimeno; *Ciutar Sanitària de Bellvitge, Hospitalet de Llobregat:* A. Díaz Prieto, H. Torrado; *Hospital Joan XXIII, Tarragona:* J. J. Guardiola, C. Boqué; *Consorci Hospitalari i Unitat Coronària de Manresa, Manresa:* M. Guirado-Alaiz; *Hospital Arnau de Vilanova, Lleida:* F. Iturbe, C. Barberà, C. Rabasso; *Hospital Mútua de Terrassa, Terrassa:* J. M. Nava, F. Jara, M. Alvarez del Castillo; *Hospital de la Santa Creu i Sant Pau, Barcelona:* A. Roglán, A. Net; *Hospital de l'Aliança, Barcelona:* J. Ruíz, L. García; *Hospital Germans Trias i Pujol, Badalona:* X. Sarmiento, J. M. Toboso; *Hospital del Mar, Barcelona:* J. Solsona, A. Alvarez; *Hospital General de Catalunya, Sant Cugat del Vallès (Barcelona):* M. Nolla; **Switzerland:** *Country Coordinator:* A. de Torrenté; *University Hospital, Zürich:* P. C. Baumann, H.-M. Vonwiller; *Regional Hospital "La Carita," Locarno:* G. Domenighetti, D. Erba; *University Hospital, Genéve:* J. C. Chevrolet, Ph. Jolliet; *University Hospital, Lausanne:* R. Chioléro, A. Messikommer; *City Hospital "Les Cadolles," Neuchâtel:* J. F. Enrico, R. Kehtari; *Community Hospital, La Chaux-de-Fonds:* A. de Torrenté, A. Kocher; *"Bürger" Hospital, Solothurn:* G. Lupi; *Kanton Hospital, Chur:* A. Frutiger, M. Reigner; *University Hospital, Basel:* R. Ritz, S. Durrer; *University Hospital, Lausanne:* C. Perret, M. D. Schaller; *University Hospital, Genève:* P. Suter, B. Ricou; **United Kingdom:** *Country Coordinator:* J. Bion; *Queen Elizabeth Hospital, Birmingham:* J. Bion, M. Bowden; *John Radcliffe Hospital, Oxford:* C. Garrard; *Southampton General Hospital, Southampton:* B. Randalls; *Royal Devon and Exeter Hospital, Exeter:* I. Wilson; **United States:** *Country Coordinator:* D. Teres; *Saint Michael's Medical Center, Newark, NJ:* M. Adelman, R. A. Miller, B. Quinones; *Oregon Health Sciences University, Portland:* C. L. Baer, J. Schwamacher, L. Renner; *Maine Medical Center, Portland:* P. M. Cox, S. Prato; *Albany (NY) Medical Center:* I. A. Fein, A. Veeder; *Dartmouth-Hitchcock Medical Center, Hanover, NH:* A. Gettinger, K. Holmes; *Saint Vincent's Hospital and Medical Center, New York, NY:* M. E. Astiz, J. Saxon, G. DeGent; *East Pasco Medical Center, Zephyrhills, Fla:* L. Grossbard, R. Ruchti; *Hermann Hospital, Houston, Tex:* G. Gutierrez, C. Clark, J. Witherspoon; *South Shore Hospital, South Weymouth, Mass:* F. Harris, M. Higgins; *State University of New York Health Science Center, Syracuse:* M. S. Jastremski, A. Milewski, K. Bunch; *Mercy Hospital, Springfield, Mass:* G. Karras, C. Barghoud, N. Richard; *Buffalo (NY) General Hospital:* F. V. McL. Booth, R. Kerins, J. Booth; *Saint Vincent Hospital, Worcester, Mass:* S. A. Nasraway, F. D. Sottile, P. Sigel; *The Genesee Hospital, Rochester, NY:* C. R. Ortiz, J. Cromiller; *Saint Elizabeth's Hospital, Boston, Mass:* K. A. Porter; *Saint Francis Medical Center, Pittsburgh, Pa:* H. Rafkin, S. Ermakov; *Medical College of Virginia, Richmond:* S. Retchin, H. D. Reines, M. Casado; *Riverside Methodist Hospital Columbia, Ohio:* H. Rogove, S. Morrow, K. Chupka, E. Foster; *New England Medical Center, Boston, Mass:* S. D. Schwaitzberg, J. Hayes, J. Scaramuzzi; *Geisinger Medical Center, Danville, Pa:* J. L. Smith, R. Burns, D. Hammaker; *Baystate Medical Center, Springfield, Mass:* D. Teres, C. Desrosiers, A. Moineau; *Mercy Hospital, Pittsburgh, Pa:* D. Thompson, M. E. Sipperly; *Akron (Ohio) General Medical Center:* D. Heiselman, T. Hofer, R. Vidovich; *Lahey Clinic Medical Center, Burlington, Mass:* J. M. O'Donnell, A. Gray, F. G. Davis; *Hermann Hospital, Houston, Tex:* A. S. Tonnesen, L. S. Cronin, C. Jennings.

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