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# Prospective assessment of the standardized mortality ratio (SMR) as a measure of quality of care in an intensive care unit — a single-centre study

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## Abstract

**Background:** The standardized mortality ratio (SMR) is a recognized indicator of critical care quality. This ratio is used to compare actual hospital mortality of all patients treated in an Intensive Care Unit (ICU) with predicted mortality. The aim of this study was a prospective analysis of SMR as a measure of the quality of care in a single ICU.

**Methods:** A prospective study was performed during a 12-month period in the ICU of the Czerniakowski Hospital in Warsaw. Predicted hospital mortality was calculated using the SAPS 3 model. The value of the SMR was evaluated in three risk groups (low, moderate, and high risk) and included the surgical status of patients (nonoperative, after elective or emergency surgery).

**Results:** A total of 341 patients were included. The SMR in the general population was 0.98 (95% CI 0.74–1.28). In the low- and high-risk groups, the value of the SMR did not differ significantly from 1. In the average risk group, as well as among patients undergoing elective surgery, the value of the SMR tended to exceed 1.

**Conclusions:** In groups of patients with low and high risk, the values of the SMR indicated a favourable quality of care. Study results should prompt a detailed analysis of the course of treatment for patients with an average risk of death. Analysis of the treatment course and qualification criteria for surgery in patients undergoing elective surgery is also indicated.

**Key words:** intensive care, mortality, standardized mortality ratio; intensive care, quality

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The scope of intensive care services involves the treatment of patients with life-threatening conditions; this is one of the major challenges of modern medicine. Moreover, intensive care consumes the highest amount of financial resources proportionally in all healthcare systems. In 2005, the cost of intensive care in the United States was estimated to be 4.1% of the healthcare expenditure, including 13.4% of total expenditures for hospital treatment, which constituted 0.66% of the gross national product [1, 2]. Considering the well-known problems associated with financing Polish healthcare services, it is essential to determine the effectiveness of resource allocation.

In 2009, the European Society of Intensive Care Medicine (ESICM) took the initiative to gather the representatives of both national and international intensive care societies in order to elaborate the guidelines that aim to improve the treatment outcomes in intensive care. The conclusions were formulated in the Declaration of Vienna [3]. The authors drew attention to many elements, e.g., a suitable number of qualified personnel per 1 station, as well as communica-

tion and cooperation in the physician and nurse teams. It was decided that the first step towards improvement was systematic monitoring of the quality of treatment.

The most natural indicator of the quality of treatment in the intensive care unit (ICU) seems to be the mortality of patients. In the literature, hospital mortality is the term that is most commonly used; hospital mortality accounts for deaths during ICU hospitalization and deaths after discharge from the ICU to other departments. However, hospital mortality alone does not reflect the quality of the therapy that was administered. Information that is more reliable is provided by the ratio of observed-to-expected mortality, as estimated by admission that is based on the severity of the disease. The disease severity is defined according to the scale that is accepted in a given unit [4]. APACHE and SAPS scoring systems are most commonly applied.

A tool used to analyse the relationship mentioned above is a standardized mortality ratio (SMR). The SMR is a quotient of the actual hospital mortality of patients who are treated in the ICU and the expected mortality.

An SMR < 1 indicates that the actual mortality is lower than the expected one; thus, the quality of therapeutic management is considered to be appropriate. An SMR > 1 means that the actual mortality is higher than the expected one, which is evidence of poor quality of service. Monitoring the SMR allows for checking the effects of the changes that are introduced, both organisational and therapy-related ones, on treatment outcomes of patients within a single unit. Moreover, it serves to compare the quality of work in various departments.

The reliability of the SMR increases with increased disease severity–associated homogeneity of the studied population. Therefore, in severity-diverse populations, it is recommended to analyse SMR values in groups of patients characterised by comparable illness severities.

Moreover, it is worth mentioning that in 2009, the SMR was accepted by ESICM as one of 9 indices to assess the quality and safety of intensive care [5] (Table 5).

The aim of the present study was a prospective evaluation of the quality of the treatment of patients in a single intensive care unit based on the SMR.

**Table 1.** Indices of quality and safety in ICUs according to ESICM [5]

| No. | Index |
|---|---|
| 1 | The unit fulfils the national standards for intensive care units |
| 2 | 24-hour availability of an intensive care specialist |
| 3 | Systems of reporting adverse events in the unit |
| 4 | Routine, daily, interdisciplinary rounds |
| 5 | Standard discharge chart containing key elements of stay |
| 6 | SMR reporting and analysing |
| 7 | Percentage of re-admissions to ICU within < 48 h |
| 8 | Percentage of catheter-related bloodstream infections |
| 9 | Percentage of unplanned extubations |

## METHODS

The study was conducted in the Intensive Care Unit (ICU) of the Czerniakowski Hospital in Warsaw. The Czerniakowski Hospital is a 290-bed healthcare centre that is financed by contracts with the National Health Fund (NHF). In 2013, 13 164 patients were treated at the Czerniakowski Hospital. In addition to the Department of Anaesthesiology and Intensive Therapy, the hospital includes the following departments: Hospital Emergency, Internal Medicine Diseases, General Surgery, Otolaryngology, Orthopaedic Trauma Surgery, Neurology, Ophthalmology and Rehabilitation. After a thorough modernization in 2013, the ICU is equipped with 9 stations, including one isolation room, and is a secondary referral unit.

The objective of the present study was to prospectively analyse the data regarding the expected and observed mortality of all patients who were treated in the ICU in a 12 month period (1.02.2013–31.01.2014). All patients who were admitted to the ICU in the analysed period were included.

The basic characteristics of the study population included age, gender, place of admission, surgical status (non-operative, after elective/emergency surgeries), duration of ICU stay, duration of mechanical ventilation, mean TISS-28 scores, ICU mortality and hospital mortality. ICU mortality was defined as the percentage of patients who died in the ICU, whereas hospital mortality was defined as the percentage of patients who died both in the ICU and after transfer from the ICU to another hospital department.

In the present study, total hospital mortality of the population studied as well as mortality accounting for the individual risk of death of a patient and his/her surgical status were analysed. The following formula was applied to calculate SMR:

SMR = actual hospital mortality/ predicted mortality

The severity of patients` conditions was assessed upon ICU admission according to the simplified acute physiology score 3 (SAPS 3). Predicted mortality was calculated automatically based on an algorithm available on the SAPS 3 Outcomes Research Group website after the suitable data were entered into the database [6]. The SAPS 3 model was prepared in 2005 based on the data from 16.784 patients who were treated in 303 intensive care units in 35 countries [7–9]. The SMR results were presented in the global model, taking into account standardization for Eastern Europe.

Additionally, the SMR was calculated separately for patients with low, moderate and high risks of death according

**Table 2.** General characteristics of the study population: numbers, medians (IQR) or means ± SD

| | |
|---|---|
| Number of patients | 341 |
| Males/females | 184/157 |
| Median age (years) | 71 (23) |
| Mean SAPS 3 score on ICU admission | 70 ± 21.23 |
| Duration of ICU stay (days) | 3 (6) |
| Number of mechanically ventilated patients | 252 |
| Length of mechanical ventilation (days) | 3 (6) |
| Mean 24 h TISS-28 score | 33 (13) |

**Table 3.** Places from which the patients were admitted to the ICU

| Place | Number of patients |
|---|---|
| Hospital Emergency Department | 109 (32) |
| General Department | 68 (20) |
| Intensive medical care unit/ intensive supervision room | 65 (19) |
| Operating suite | 72 (21) |
| Another hospital | 27 (8) |

to SAPS 3. The criteria were determined assuming the risk of death to be < 10%, 10–50% and > 50%, respectively [10], which corresponds to respective SAPS 3 scores of < 44, 44–67 and > 67. Moreover, the SMR was analysed according to surgical status: non-operative patients, after elective surgeries and after non-elective surgeries (emergency or urgent).

Results were presented in absolute values and percentages. Normally distributed data were presented as an arithmetic mean and standard deviation, and those with a non-normal distribution were presented as median and interquartile range (IQR). The SMR was presented with a 95% confidence interval (95% CI) calculated with the Poisson process using chi-square transformations. SMR values were considered to be significant when the confidence interval did not include 1.

## RESULTS

The general characteristics of the study group are presented in Table 2. Patients were admitted to the ICU from the Emergency Department and other hospital departments. Some patients were also admitted from other hospitals (Table 3).

Table 4 provides the data regarding the mortality of patients and the calculated SMR with regard to the entire population that was studied.

The data calculated for groups of low, moderate and high risks of death are presented in Table 5. Over half of all the patients treated in the ICU fulfilled the criterion of a high risk of death that was assumed in the study. The SMR did not differ significantly from 1 in any of the groups that were analysed; however, a tendency to lower SMR values was observed in the low-risk group, whereas a tendency to higher SMR values was observed in the moderate-risk group.

**Table 4.** Mortality and SMR for the entire study population

| Parameter | |
|---|---|
| Number of patients | 341 |
| ICU mortality, n (%) | 148 (43.4) |
| Hospital mortality, n (%) | 191 (56.01) |
| SMR (95% CI) | 0.98 (0.74–1.28) |
| SMR for Eastern Europe (95% CI) | 0.84 (0.6–1.09) |

**Table 5.** Mortality and SMR according to the death risk group

| Risk of death | Low risk | Moderate risk | High risk |
|---|---|---|---|
| Number of patients (%) | 41 (12) | 117 (34) | 183 (54) |
| Hospital mortality (%) | 1 (2.44) | 43 (36.75) | 147 (80.33) |
| SMR (95% CI) | 0.61 (0.09–1.97) | 1.31 (0.92–1.81) | 0.99 (0.79–1.23) |
| SMR for Eastern Europe (95% CI) | 0.81 (0.13–2.63) | 1.23 (0.86–1.69) | 0.88 (0.7–1.09) |

**Table 6.** Mortality and SMR according to surgical status

| Surgical status | Non-operative | Elective surgery | Emergency surgery |
|---|---|---|---|
| Number of patients (%) | 227 (67) | 34 (10) | 80 (23) |
| Hospital mortality (%) | 139 (61.23) | 8 (23.53) | 44 (55) |
| SMR (95% CI) | 0.99 (0.76–1.27) | 1.47 (0.94–2.19) | 1.06 (0.79–1.38) |
| SMR for Eastern Europe (95% CI) | 0.84 (0.64–1.08) | 1.57 (0.99–2.34) | 0.89 (0.67–1.15) |

Table 6 presents the characteristics of patients according to surgical status. The majority of patients treated in the ICU were non-operative. Patients after non-elective surgery predominated amongst the surgical patients. In the group after elective surgery, hospital mortality was found to be lower. The SMR did not differ significantly from 1 in any of the study groups; however, a tendency to higher values was observed in the group after elective surgery.

## DISCUSSION

Hospital mortality of patients treated in the ICU analysed, which exceeded 50%, differs from the data from other European countries. For instance, hospital mortality in Scan-

dinavian countries does not exceed 9% [11], and in Italy, hospital mortality is 16% [12]. The Polish data only take into account ICU mortality. The results of the National Institute of Public Health indicate a 50% mortality in intensive care units (Centre for Monitoring and Analyses of Public Health: Research on Hospital Morbidity). The study findings reported by Prof. Piotr Knapik during the International Congress of the Polish Society of Anaesthesiology and Intensive Therapy in Wisła in 2014 concerning the Silesian region demonstrate that ICU mortality exceeds 40%, which is not significantly different from the data that is presented in our study.

Does absolute mortality then mean that patients in our ICU are treated badly? The level of mortality is a resultant of many elements, e.g., proper qualification of patients to the ICU, severity of their conditions on admission, quality of treatment administered, time and method of discontinuation of futile therapy of patients whose recovery is not prognosticated.

Therefore, for proper interpretation of mortality rates, a parameter is needed to refer its absolute value to the risk of death resulting from the patient's condition on admission; the corresponding parameter in our study was the SMR.

Analysis of SMR values in the study population shows that its mean value does not differ from 1. This evidences a good quality of treatment, despite a high absolute mortality of patients, which can largely result from the fact that patients who are qualified for ICU treatment have more advanced stages of diseases compared to the majority of European countries and from difficulties in transferring patients who do not require intensive care to other departments and palliative-hospice care centres.

The problems mentioned above were recognized and addressed by the Polish Society of Anaesthesiology and Intensive Therapy, which published the guidelines regarding criteria for ICU admissions [13] and the management guidelines in cases of the ineffective maintenance of organ functions (futile therapy) [13]. According to their authors, the documents are of pivotal importance because they enable addressing intensive care only for patients whose treatment is likely to be effective.

Despite the general acceptance of SMR, it has its limitations. The presence of a higher number of high-risk patients in a given population contributes to a disproportional increase in SMR simply because more such patients die. Therefore, the unit that is characterized by the treatment outcomes better than the expected ones in the group of low- and moderate-risk patients can have a mean SMR value >1 if the treatment outcomes in the high-risk group are worse than the expected ones, even when the group size is small [15]. Considering the above, we decided to calculate SMR separately for high-, moderate- and low-risk patients.

Moreover, it should be taken into account that the result obtained could be significantly affected by incidental factors, particularly in small-sized groups. Therefore, we decided to use additional 95% confidence intervals for the validation of SMR values. An SMR confidence interval containing 1 means there are no grounds to consider that the calculated SMR value is significantly different from 1. In our material, SMRs did not differ from 1 in any of the subgroups that were analysed. Generally, an extremely wide confidence interval (higher than 0.5) results from small sizes of groups and is strongly affected by incidental factors; thus, the results should be interpreted with caution. In our material, this particularly concerns the group of patients undergoing elective surgeries.

The results of the present analysis indicate a high percentage of patients with the highest risk of death (over half of treated patients). Apart from the factors discussed above, it is worth considering whether this phenomenon does not result from late identification and admission to ICU of patients with life-threatening conditions. High absolute mortality in this group was accompanied by a satisfactory SMR, which is evidence that therapeutic activities undertaken in the group of the most seriously ill patients were satisfactory. While the SMR values obtained in the group of low- and moderate-risk patients were satisfactory, in the high-risk group, the tendency to SMR values higher than 1 was observed (both globally and standardised for Eastern Europe). Although the confidence interval for SMR in the group of moderate risk of death contains 1, the tendency to the increased SMR values that were observed leads to the analysis of the therapeutic process in this group of patients.

In our study, the quality of care according to the surgical status of patients was analysed as well. The absolute mortality that was found in these subgroups contrasts with the results from other developed countries. For instance, the data collected in Australia and New Zealand reveal that hospital mortality in intensive care patients in non-operative groups, after elective and non-elective surgeries was 13–19%, 1–3% and 5–13%, respectively [16]. Polish data regarding the mortality of ICU patients who underwent surgeries are not known.

In this context, special attention should be paid to the group of patients undergoing elective surgeries. In our study, this group was characterized by the lowest hospital mortality; however, the tendency to high SMR values (the highest one among all groups that were analysed) attracts attention. The confidence interval in the groups discussed is wide, which can indicate the diversity of the group or a considerable impact of incidental factors. It should be emphasized, however, that even a statistically diverse risk of excessive mortality amongst patients undergoing elective

surgeries should arouse increased vigilance and lead to a detailed analysis of the qualification of patients for surgical treatment, course of the postoperative period and types of surgical procedures administered.

The key aim of the present study was to evaluate the use of SMR as a tool for assessing the quality of therapeutic management. Therefore, the medical aspects of the data that were obtained, such as mechanical ventilation time and indications and severity of patients` conditions on ICU admission, were not analysed; the focus of the attention was on the elements affecting the quality assessment. The evaluation of SMR is relatively simple; nevertheless, it provides valuable information about the quality of the service of intensive care units. Together with the other recommended indices, it allows for complex assessment of the quality of the services that are provided. The monitoring and analysis of SMR enables the analysis of the function of the intensive care unit itself and of hospital management protocols for life-threatening conditions. When any infringements are noticed, early institution of corrective measures is possible.

SMR not only enables the evaluation of the quality of the therapeutic process within one unit but is also a recognised measure to compare various intensive care units. The assessment and comparison of the quality of treatment in various units can be a positive stimulus confirming the usefulness of self-involvement in the treatment, thus incentivising further development both in the organizational and medical sphere. The above regards both the individual unit scale and the countrywide scale. Countrywide monitoring of the quality of intensive care was implemented in the majority of highly developed countries, and functions with success in countries such as Great Britain, Sweden and Finland [17–19].

The results presented in our study should be considered as a contribution to the discussion on the improvement of work in the analysed unit and to the elaboration of the universal model of monitoring of the quality of intensive care, which can be widely applied under Polish conditions. In our opinion, SMR reporting should be one of the elements for the Polish registry of anaesthesiology and intensive care.

## CONCLUSIONS

1. The results in the group of low and high risk of death evidence a good quality of treatment.
2. The findings encourage a detailed analysis of the treatment of patients with a moderate risk of death, including course of treatment and qualification of patients undergoing elective surgeries.

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