Retrospective Assessment of the Standardized Mortality Ratio as a Measure of the Quality of Care in a Major Intensive Care Unit in the Republic of Cyprus

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***Introduction**: The standardized mortality ratio (SMR) is commonly used to assess the overall quality of care by comparing the observed hospital mortality with the mortality predicted by statistical models. If the observed deaths are less than the predicted, the overall quality of care can be considered high; in the opposite case, it is low. **Aim**: The aim of the study was to assess the overall quality of care in an intensive care unit (ICU) during the period of 2012 to 2017. We also reported our experience and lessons learned throughout the surveillance period. **Methods**: A retrospective study design was adopted. Healthcare-associated infections (HAI–ICU) protocol v1.1 was used in a major ICU for a period of 6 years. All patients admitted to the ICU during the surveillance period were included in the study. The SMR was measured. **Results**: During the 6-year period, 1067 patients were admitted and remained hospitalized for more than 48 hours; 207 patients' discharge status was reported as "death", compared to 309 deaths predicted based on the SAPS II score. The overall mean observed mortality rate during the study period was 19.4%, as opposed to 28.95% for the predicted mortality. The overall mean SMR was 0.62 (IQR 0.49-0.82). Difficulties were faced due to the lack of surveillance software, but they were overcome by the use of a freely available web-based form. **Conclusions**: The overall quality of ICU care is considered to correspond to high-quality standards, since standardized mortality rates during the study period were lower than one. The use of the web-based form as an alternative solution to the surveillance software performed well in terms of recording data.*

Keywords: standardized mortality ratio; ICU; quality of care; mortality rate; SMR

INTRODUCTION

The aim of intensive care units (ICU) is providing intensive care to patients with complex, severe, and life-threatening conditions. Despite their importance for patients' outcomes, ICUs account for one of the highest proportions of costs in healthcare systems. According to the published literature, although ICUs account for only 10% of hospital beds, they consume nearly 22% of the hospital's resources (Halpern, Bettes, & Greenstein, 1994; Kumar, Jithesh, & Gupta, 2016). Therefore, it is important to ensure that the high resource use is reflected in a high quality of ICU care with improved patients' outcomes. Consequently, the

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assessment of the quality of care delivered in the ICU setting is of high priority for healthcare systems.

The standardized mortality ratio (SMR) is commonly used to assess the performance of ICUs (Naing, 2000). SMR has been defined as the ratio of the observed mortality versus the predicted mortality for a specified time period in a specific population (Loirat, 1995; Ridley, 1998). The predicted mortality is commonly calculated by using severity scoring systems such as the Simplified Acute Physiology Score (SAPS II; Le Gall, Lemeshow, & Saulnier, 1993) or the Acute Physiology and Chronic Health Evaluation (APACHE II; Knaus, Draper, Wagner, & Zimmerman, 1985).

The European Society of Intensive Care Medicine (ESICM) created an expert task force of representatives of intensive care societies in 2009, in order to elaborate the guidelines that aim to improve the quality of care and treatment outcomes (Moreno, Rhodes, & Donchin, 2009). Later on, SMR was recognized by ESICM as one of the nine indicators for assessing the quality of care in ICUs. These nine indicators obtained over 75% consensus from the group of experts in the final stage of the Delphi process and they include: SMR, 24-hour intensivist, reporting adverse events in ICU, proportion of patients readmitted in ICU, standard discharge letter that is reporting the care received during ICU stay, bloodstream infections proportion associated with central vein catheterization, ICU design according to national standards, daily interdisciplinary rounds and percentage of unplanned extubations (Rhodes et al., 2012).

SMR results lower than 1 indicate that the overall quality of care in a specific ICU population for a specific time period is appropriate, since the observed mortality is lower than that predicted by scoring systems (Knaus et al., 1985; Le Gall et al., 1993). Results higher than 1 indicate the opposite, namely that the observed mortality is higher than the predicted, therefore the overall quality of care is worse than expected.

The current study presents the first attempt to assess the quality of care using the SMR indicator, in a major ICU in the republic of Cyprus. We also report the experience of organizing and implementing reporting of severity and related quality indicators, as well as challenges, barriers, and the ways we mitigated them. Our experience might inform the implementation of ICU quality assessment efforts in low resource healthcare settings without an integrated hospital information system.

MATERIALS AND METHODS

Aim

The aim of the study was to retrospectively evaluate the quality of care in a major ICU in the Republic of Cyprus, by assessing SMR, for a period of 6 years measured.

Design and Population

We employed a retrospective correlational design. Patients who were admitted in the ICU and remained hospitalized for more than 48 hours during a 6-year period (January 1, 2012 –December 31, 2017) were included in this analysis. Patients who transferred from other ICUs and met above criteria were also included in the study. Exclusion criteria included: ICU length of stay of less than 48 hours, patients younger than 16 years of age, and patients who transferred to other ICUs.

Setting

The study was conducted in the ICU of a major public secondary general referral hospital in the Republic of Cyprus, with 28,000 yearly hospital admissions. Patients admitted to the ICU are older than 16 years of age. The unit is a closed adult ICU, of open plan, case mixed, with eight beds and is receiving patients from private and public hospitals across the Republic of Cyprus.

Data Collection and Measures

Data were collected using the HAI-ICU ECDC protocol, which is being activated 48 hours after ICU hospitalization (ECDC-NHSN, 2010). The predicted mortality rates of patients were reflected as SAPS II score which was retrospectively calculated. Although SAPS II and APACHE II scores are being both used in the aforementioned surveillance protocol, only SAPS II has been used in the current study. The accuracy of the prediction models is at its best when it matches the patients in the development population. The APACHE score, for instance, was largely based on North American populations and the SAPS score on European patients (Rhodes et al., 2012). Since the Republic of Cyprus belongs to EU countries, SAPS II score was decided to be used for the calculation of SMR. In addition, SAPS II and APACHE II appear to have similar value in predicting mortality (Aminiahidashti, Bozorgi, Montazer, Baboli, & Firouzian, 2017; Naqvi, Mahmood, Ziaullaha, Kashif, & Sharif, 2016).

Observed mortality was defined as the proportion of patients who died during the ICU hospitalization during the study period. SMR was calculated using the observed mortality devided by the predicted mortality.

All data were anonymously collected in a way that data could not be traced back to a specific patient. For advanced security, a two-step verification was activated, meaning that none except the healthcare professionals had access to data collected by the form.

Statistical Analysis

Medians and interquartile ranges (IQR) were used to describe the distribution of continuous variables, and frequencies and percentages for categorical variables. SMR was computed with 95% confidence intervals (CI) using IBM-SPSS software, version 24 (IBM SPSS Inc., 2012).

RESULTS

During the study period, 1067 patients were admitted and remained hospitalized for more than 48 hours. The surveillance period with the fewest admissions was the year 2012 (n = 145) and the highest rate of admissions occurred in 2017 (n = 216). In general, a stable increase in the number of patients admitted to ICU during the years was noticeable; and the overall number of males [603 (56.52%)] was more than female patients [464 (43.48%)]. The overall median age in years was 66.5 (IQR 50–76), and the length of ICU stay was 7.5 (IQR 3-17) days.

An increase was also noticed in the SAPS II score amongst patients admitted during the study period (48 in 2012 and 57 in 2017, respectively). The highest SAPS II score was found in 2016 (60 IQR 42.25–73), and the lowest in 2013 (47 IQR 34–62.5).

The most frequently encountered admission diagnosis was medical [709 (66.44%)], followed by unscheduled surgical [294 (27.55%)]; surgical reasons [64 (5.99%)] was the least frequent of admission. Most patients had been transferred from a ward of the same or another hospital [462 (43.29%)], followed by transfers from the community [319 (29.89%)], other ICU [254 (23.8%)], and long term care facilities [27 (2.5%)].

During the study period, 207 patients died in the ICU, while the predicted mortality according to SAPS II estimations was 309. During the year 2012, 148 patients were admitted and 26 died in the ICU, while the predicted deaths were 48, resulting in the calculated SMR of 0.54. In 2013, 165 patients were admitted, 33 died compared to 48 expected deaths, and the SMR was 0.70. In 2014, 159 patients were admitted with 28 observed deaths, compared to 47 predicted, yielding an SMR of 0.40. In 2015, 198 patients were admitted, 41 died, as opposed to 49 predicted deaths and SMR was 0.83. In 2016, 184 were admitted with 32 observed and 60 predicted deaths respectively, contributing to aSMR of 0.53. In 2017, among 216 admissions, we observed 47 compared to 57 predicted deaths, and a SMR of 0.82. The overall SMR was found to be 0.62 (IQR 0.49–0.82). The highest observed mortality rate (OMR) was found in 2017 (OMR, 0.21), and the lowest in 2014 (OMR, 0.18; Table 1).

TABLE 1. Demographic Characteristics and Standardized Mortality Ratio Across the Surveillance Periods

Characteristic	2012 Patients n = 145		2013 Patients n = 165		2014 Patients n = 159		2015 Patients n = 198		2016 Patients n = 184		2017 Patients n = 216		Overall N = 1,067	
	n (%)	Median (IQR)	n (%)	Median (IQR)	n (%)	Median (IQR)	n (%)	Median (IQR)	n (%)	Median (IQR)	n (%)	Median (IQR)	N (%)	Median (IQR)
Sex														
Female	54 (37.1)		58 (35.4)		47 (29.7)		73 (36.9)		71 (38.6)		90 (41.7)		464 (43.48)	
Male	91 (62.9)		107 (64.6)		112 (70.3)		125 (63.1)		113 (61.4)		126 (58.3)		603 (56.52)	
Age in years		65 (50–74)		65 (52.5–72)		65 (53–74)		68 (55–77)		71.5 (59.25–78)		68.5 (51–76)		66.5 (50–76)
Length of ICU stay (days)		8 (5–14)		8 (5–16)		8 (4–17)		6 (4–13)		6 (3–13)		7 (4–13.75)		7.5 (3–17)
SAPS II[a]		48 (35–61)		47 (34–62.5)		48 (32–62)		49 (36–65)		60 (42.25–73)		57 (40–70)		48.8 (32–73)
Type of admission														
Medical	99 (68.5)		104 (62.8)		83 (51.9)		141 (71.2)		127 (69)		155 (71.8)		709 (66.44)	
Planned surgical	6 (4.2)		12 (7.3)		24 (15.2)		3 (1.5)		9 (4.9)		10 (4.6)		64 (5.99)	
Unplanned surgical	40(27.3)		49(29.3)		52(32.9)		54(27.3)		48(26.1)		51(23.6)		294(27.55)	
Origin of patient														
Community	35(23.8)		47(28.7)		50(31.6)		63(31.8)		61(32.6)		63(29.6)		319(29.89)	
LTCF[b]	3(2.1)		4(2.4)		2(1.3)		4(2)		9(4.9)		5(2.3)		27(2.5)	
Other ICU	36(25.2)		35(21.3)		40(24.7)		43(21.7)		48(26.1)		52(24.1)		254(23.8)	
Ward	71(49)		76(45.7)		67(41.8)		88(44.4)		66(35.9)		94(43.5)		462(43.29)	

(*Continued*)

TABLE 1. Demographic Characteristics and Standardized Mortality Ratio Across the Surveillance Periods (*Continued*)

Characteristic	2012 Patients *n* = 145		2013 Patients *n* = 165		2014 Patients *n* = 159		2015 Patients *n* = 198		2016 Patients *n* = 184		2017 Patients *n* = 216		Overall *N* = 1,067	
	n (%)	Median (IQR)	*n* (%)	Median (IQR)	*n* (%)	Median (IQR)	*n* (%)	Median (IQR)	*n* (%)	Median (IQR)	*n* (%)	Median (IQR)	*N* (%)	Median (IQR)
Trauma	30(21)		27(15.9)		39(24.1)		27(13.6)		29(15.8)		30(13.9)		182(17.05)	
Impaired immunity	32(22)		27(15.7)		30(19)		38(19.2)		14(7.7)		27(12.5)		168(15.74)	
Antimicrobial treatment	127(87.4)		154(93.3)		137(86.1)		180(90.9)		167(90.8)		203(94)		968(70.72)	
Observed deaths	26		33		28		41		32		47		207	
Observed mortality rate	17.93%		20%		17.61%		20.7%		17.39%		21.75%		19.4%	
Predicted deaths by SAPS II score	48		47		48		49		60		57		309	
Predicted mortality rate	33.1%		28.48%		30.18%		24.74%		32.6%		26.26%		28.95%	
SMR[c]	0.54		0.70		0.40		0.83		0.53		0.82			0.62 (0.49–0.82

[a]Simplified acute physiology score II. [b]Long-term care facility. [c]Standardized mortality ratio.

SURVEILLANCE CHALLENGES, BARRIERS, AND MITIGATION

Several barriers can interfere with the successful implementation of surveillance procedures in the ICU. Amongst others, the most important barriers and challenges in our study were the lack of surveillance software, lack of hardware and lack of access to the hospital-wide network, as well as the lack of people willing to be involved in the surveillance. The majority of the surveillance software are expensive, and no funding sources were available. To successfully implement our surveillance, we thoroughly searched for an alternative solution.

For the reasons of the study, the HAI-ICU protocol paper form that is freely available through European Centres of Disease Control (ECDC) was used. Although, a software application for the manual entry of surveillance data is freely available for download from ECDC's website (European Centre for Disease Prevention and Control, n.d.), difficulties were encountered due to its fitting and easiness of use, and consequently, we made a decision to not use it. We instead used the freely available, web-based, Google forms to substitute the surveillance software. We converted the paper form of ECDC HAI-ICU protocol to an electronic survey with the use of Google forms. It was adequately easy to use by healthcare personnel, and it can be used on any device with any software, with any browser, as long as the network and a browser are available. All the data were linked to an excel file that can be downloaded and be used in statistical software. One of the most useful features of the aforementioned survey was that the use of the "answers summary" feature which provided the unit with almost, live surveillance of the data in form of figures, without the need for a statistical program.

Our experience might inform the implementation of ICU quality assessment efforts in low resource healthcare settings, without an integrated hospital information system.

DISCUSSION

In this study, we employed SMR assessments as a surrogate measure of the quality of care in our ICU. In absolute numbers, the predicted by SAPS II death rate was substantially higher compared to the observed death rate, possibly denoting a high quality of care. Nonetheless, the use of SMR bears specific limitations. SMR ignores the deaths that can occur soon after the discharge, which could be affected by end of life decisions and missing surveillance data. It takes into consideration only the "death" reported status without including any disability and factors that affect the quality of life after the ICU hospitalization. It is also significantly affected by the scoring system used to calculate the predicted mortality, especially if it is not unit-based calibrated, and the quality of input data (Rhodes et al., 2012). However, SMR remains a widely used indicator of overall quality of ICU care that can be used for the comparison of the same type of ICUs, and for the monitoring of improvements or declines in ICU care, as well as to compare hospital-wide SMR.

During the study period, we noticed a progressive increase in the yearly admissions and underlying disease severity scores of patients. Specifically, comparing admissions of the initial period (2012) with those of 2017, an increase of 71 patients was noted, along with higher SAPS II scores. The reasons for increased severity are undefined, but the findings showed that the ICU faced difficulties in dealing with the increasing number and disease severity of patients, as reflected in mortality rates. Indeed, it is well documented that overcrowded ICUs and increased nursing workload are associated with a substantial reduction in the odds of survival (Lee et al., 2017). Thus, actions are needed from the perspective of implementation of a patient admission protocol, in a way to avoid unnecessary admissions.

Admission protocols could be supported but not guided by scoring systems. Although scoring systems can predict the likelihood of death with an acceptable margin of error, these scores are not being used for decisions around ICU admission, to withdrawal or to withhold treatment. A recent French study concluded that further research is needed to exactly define the role of SAPS II score, especially in end-of-life decision-making in ICUs (Allyn et al., 2016). Thus, they provide the likelihood of death, but they cannot account for subsequent alterations in patients' status. The aforementioned phenomenon is also supported by the findings of the current study. Moreover, the latest version of the score, SAPS 3, tends to overestimate the probability of death and to result in predictions that are higher than the observed (Poncet, Perneger, Merlani, Capuzzo, & Combescure, 2017). A Swiss nationwide survey found that SAPS II estimations can be higher up to 13% (Previsdomini et al., 2014). However, SAPS II is still among the most widely used scoring systems in critically ill patients (Bouch & Thompson, 2008; Naing, 2000). A unit-based SAPS II calibration may be the appropriate step for more precise death estimation, since its accuracy for mortality prediction depends not only on patient characteristics, but also on center characteristics (Poncet et al., 2017). This is also supported by the Task Force on Safety and Quality of the ESCIM (Rhodes et al., 2012).

The progressively increasing disease severity of patients admitted is also worth-discussing. Since the initial period (2012), the SAPS II score increased (higher score = higher severity of illness = higher probability of death) in a way that the probability of death rose up to 20–25% (median SAPS score) to the last surveillance period.

Despite limitations, SMR value during the study period indicated a high quality of care in the ICU of the study.

Limitations

The current study has certain limitations. The study was conducted only in one adult ICUs in Cyprus. These findings cannot be generalized to other public or private hospital settings. A latest version of the SAPS or a unit-based calibration of the SAPS II score may reflect with higher accuracy the estimation of predicted mortality rates. Therefore, uncalibrated SAPS II used in the current study may be overestimating or underestimating the mortality predictions.

CONCLUSIONS

Observed mortality rates were significantly lower than those predicted by the SAPS II score, and SMR were lower than one across the study period. These findings indicated that the overall quality of care provided in the ICU was at high standards; however, the limitations of SMR and SAPS II also need to be taken into account. Further study is needed to validate the use of SMR based on SAPS II in critically ill patients in Cyprus and in other European samples.

REFERENCES

Allyn, J., Ferdynus, C., Bohrer, M., Dalban, C., Valance, D., & Allou, N. (2016). Simplified acute physiology score II as predictor of mortality in intensive care units: A decision curve analysis. *PLOS ONE*, *11*(10), e0164828, 1-11. https://doi.org/10.1371/journal.pone.0164828

Aminiahidashti, H., Bozorgi, F., Montazer, S. H., Baboli, M., & Firouzian, A. (2017). Comparison of APACHE II and SAPS II scoring systems in prediction of critically ill patients' outcome. *Emergency (Tehran, Iran)*, *5*(1), e4. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/28286811

Bouch, D. C., & Thompson, J. P. (2008). Severity scoring systems in the critically ill. *Continuing Education in Anaesthesia Critical Care & Pain*, *8*(5), 181–185. https://doi.org/10.1093/bjaceaccp/mkn033

European Centre for Disease Prevention and Control. (2010). *HelicsWin.Net (HWN).* Retrieved https://www.ecdc.europa.eu/en/publications-data/helicswinnet-hwn

Halpern, N. A., Bettes, L., & Greenstein, R. (1994). Federal and nationwide intensive care units and healthcare costs: 1986–1992. *Critical Care Medicine*, *22*(12), 2001–2007. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/7988140

IBM SPSS Inc. (2012). SPSS Statistics for Windows 21, IBM Corp. Released 2012.

Knaus, W. A., Draper, E. A., Wagner, D. P., & Zimmerman, J. E. (1985). APACHE II: A severity of disease classification system. *Critical Care Medicine*, *13*(10), 818–829. https://doi.org/10.1097/00003465-198603000-00013

Kumar, P., Jithesh, V., & Gupta, S. (2016). A comparative cost analysis of polytrauma and neurosurgery Intensive Care Units at an apex trauma care facility in India. *Indian Journal of Critical Care Medicine*, *20*(7), 398. https://doi.org/10.4103/0972-5229.186220

Lee, A., Cheung, Y. S. L., Joynt, G. M., Leung, C. C. H., Wong, W. T., & Gomersall, C. D. (2017). Are high nurse workload/staffing ratios associated with decreased survival in critically ill patients? A cohort study. *Annals of Intensive Care*, *7*(1), 46. https://doi.org/10.1186/s13613-017-0269-2

Le Gall, J. R., Lemeshow, S., & Saulnier, F. (1993). Simplified Acute Physiology Score (SAPS II) Based on a European / North American multicenter study. *JAMA*, *270*(24), 2957–2963. https://doi.org/10.1001/jama.270.24.2957

Loirat, J.-R. G. (1995). Current opinion in critical care. *Current Opinion in Critical Care*, *1*(3), 219–220. Retrieved from https://insights.ovid.com/crossref?an=00075198-199506000-00011

Moreno, R. P., Rhodes, A., & Donchin, Y. (2009). Patient safety in intensive care medicine: the Declaration of Vienna. *Intensive Care Medicine*, *35*(10), 1667–1672. https://doi.org/10.1007/s00134-009-1621-2

Naing, N. N. (2000). Easy way to learn standardization direct and indirect methods. *The Malaysian Journal of Medical Sciences MJMS*, *7*(1), 10–15. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22844209

Naqvi, I. H., Mahmood, K., Ziaullaha, S., Kashif, S. M., & Sharif, A. (2016). Better prognostic marker in ICU - APACHE II, SOFA OR SAP II! *Pakistan Journal of Medical Sciences*, *32*(5), 1146–1151. https://doi.org/10.12669/pjms.325.10080

Poncet, A., Perneger, T. V., Merlani, P., Capuzzo, M., & Combescure, C. (2017). Determinants of the calibration of SAPS II and SAPS 3 mortality scores in intensive care: A European multicenter study. *Critical Care*, *21*(1), 85. https://doi.org/10.1186/s13054-017-1673-6

Previsdomini, M., Cerutti, B., Merlani, P., Kaufmann, M., Van Gessel, E., Rothen, H. U., & Perren, A. (2014). SwissScoring-a nationwide survey of SAPS II assessing practices and its accuracy. *Swiss Medical Weekly*. EMH Swiss Medical Publishers Ltd. https://doi.org/10.4414/smw.2014.14090

Rhodes, A., Moreno, R. P., Azoulay, E., Capuzzo, M., Chiche, J. D., Eddleston, J., & Valentin, A. (2012). Prospectively defined indicators to improve the safety and quality of care for critically ill patients: A report from the Task Force on Safety and Quality of the European Society of Intensive Care Medicine (ESICM). *Intensive Care Medicine*, *38*(4), 598–605. https://doi.org/10.1007/s00134-011-2462-3

Ridley, S. (1998). Severity of illness scoring systems and performance appraisal. *Anaesthesia*, *53*(12), 1185–1194. https://doi.org/10.1046/j.1365-2044.1998.00615.x

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