OPEN

The Influence of Potential Organ Donors on Standardized Mortality Ratios and ICU Benchmarking

Anssi Pölkki, MD[1,2]
André Moser, PhD[3]
Rahul Raj, MD, PhD[4]
Jukka Takala, MD, PhD[5]
Stepani Bendel, MD, PhD[1]
Stephan M. Jakob, MD, PhD[5]
Matti Reinikainen, MD, PhD[1,2]

OBJECTIVES: The standardized mortality ratio (SMR) is a common metric to benchmark ICUs. However, SMR may be artificially distorted by the admission of potential organ donors (POD), who have nearly 100% mortality, although risk prediction models may not identify them as high-risk patients. We aimed to evaluate the impact of PODs on SMR.

DESIGN: Retrospective registry-based multicenter study.

SETTING: Twenty ICUs in Finland, Estonia, and Switzerland in 2015–2017.

PATIENTS: Sixty thousand forty-seven ICU patients.

INTERVENTIONS: None.

MEASUREMENTS AND MAIN RESULTS: We used a previously validated mortality risk model to calculate the SMRs. We investigated the impact of PODs on the overall SMR, individual ICU SMR and ICU benchmarking. Of the 60,047 patients admitted to the ICUs, 514 (0.9%) were PODs, and 477 (93%) of them died. POD deaths accounted for 7% of the total 6738 in-hospital deaths. POD admission rates varied from 0.5 to 18.3 per 1000 admissions across ICUs. The risk prediction model predicted a 39% in-hospital mortality for PODs, but the observed mortality was 93%. The ratio of the SMR of the cohort without PODs to the SMR of the cohort with PODs was 0.96 (95% CI, 0.93–0.99). Benchmarking results changed in 70% of ICUs after excluding PODs.

CONCLUSIONS: Despite their relatively small overall number, PODs make up a large proportion of ICU patients who die. PODs cause bias in SMRs and in ICU benchmarking. We suggest excluding PODs when benchmarking ICUs with SMR.

KEYWORDS: intensive care unit benchmarking; mortality prediction; organ donation; quality benchmarking; standardized mortality ratio

Severity- and case-mix-adjusted mortality prediction models allow for the calculation of the standardized mortality ratio (SMR). The SMR, which represents the ratio of observed to expected mortality, is an important component of quality benchmarking of ICUs and is routinely applied by many ICU registries (1). The SMR enables comparisons of the performance of ICUs with different case mixes. Many risk prediction models have also been modified or recalibrated to improve their performance in national or regional registries (2–12).

Limiting treatment upon ICU admission is associated with an increased risk of death (13). Patients admitted for evaluation as potential organ donors (PODs) represent an extreme treatment limitation: death is anticipated and accepted, and the goal of ICU admission of the POD is not to save the patient but to protect organs for possible donation (14, 15). Accordingly, the expected

DOI: 10.1097/CCM.0000000000006098

KEY POINTS

Question: Does admission of potential organ donors (PODs) to ICUs affect standardized mortality ratios (SMRs)?

Findings: In this retrospective study on 60,047 ICU patients from three countries, PODs made up 0.9% of all ICU admissions (range across ICUs, 0.05–1.8%), but accounted for 7% of all in-hospital deaths. PODs had a much higher observed than risk model-predicted mortality (93% vs. 39%), and therefore they increased the SMRs. SMR-based benchmarking results changed for 70% of ICUs after PODs were excluded.

Meaning: PODs cause bias in SMR calculations and ICU benchmarking.

mortality should approach 100%. However, because PODs often have no other major organ dysfunctions besides severe brain injury, risk prediction models may give them erroneously low probabilities of death. In fact, most mortality prediction models do not address this concern.

The impact of POD admissions on the SMRs of ICUs and their implications on benchmarking results are unknown. We recently published a risk prediction model that excludes PODs in predicting the risk of death in ICU patients (6).

STUDY AIMS

The aim of this study was to assess how the inclusion of PODs impacts the overall SMR and the SMRs of individual ICUs. Additionally, we investigated whether the inclusion or exclusion of PODs affected the benchmark rankings of the ICUs.

MATERIALS AND METHODS

Data Extraction, Patient Selection, and Exclusion Criteria

In this secondary analysis, we used the SMR study population described by Takala et al (16). In brief, Takala et al (16) used data from the Finnish Intensive Care Consortium (FICC) database, encompassing 168,108 admissions between 2008 and 2017. Data regarding possible treatment limitations upon ICU admission are recorded in the database. Since 2015, these recordings have captured patients who are admitted for the sole purpose of possible organ donation. Thus, data on PODs were available for 2015–2017. Therefore, we restricted the SMR study population from Takala et al (16) to 2015–2017, which yielded a total of 60,047 patients from 20 ICUs in three nations—Finland (18 ICUs), Estonia (one ICU), and Switzerland (one ICU) (**eFig. 1**, http://links.lww.com/CCM/H450, for flowchart).

Ethical Considerations

The data management plan, database contents, and study process were approved by the Finnish Institute for Health and Welfare (THL/1524/5.05.00/2017; THL/1173/05/00/2018; THL/3795/14.06.00/2021). According to regulations in Finland, Estonia, and Switzerland, no ethics committee approval was needed.

Identification of Potential Organ Donors

We identified PODs if a recording of "admission because of possible organ donation" was registered at the time of ICU admission.

Calculation of the Standardized Mortality Ratio

The SMR was defined as the number of observed deaths divided by the number of predicted deaths. We used the model described by Moser et al (6) to calculate the predicted mortality risk. This model was based on age, a modified Simplified Acute Physiology Score (SAPS) II score (17) (excluding age and admission type), admission type (elective vs. emergency and surgical vs. nonsurgical admission), and premorbid functional status determined using a modified Eastern Cooperative Oncology Group (ECOG) classification (18). Importantly, in the model creation and validation, PODs were excluded. In this study, we estimated the effect of PODs on SMR by calculating the SMR in the study population with and without PODs.

Statistical Methods

We report frequencies (*n*), percentages (%), median values, and interquartile ranges. For group differences between cohorts of PODs and admissions for

other causes, we report p values using a chi-square or Wilcoxon rank-sum test. We calculated SMRs for the overall cohort and each ICU. We calculated the ratio of the SMR of the cohort without PODs to the SMR of the cohort with PODs (with 95% CIs) using multivariable Poisson regression models with a cohort-specific indicator adjusted for calendar year for the overall cohort and separately for each ICU. To assess the impact of case-mix, we modeled the overall SMR in a model with indicators for the two cohorts and hospital typology. First, we tested for an interaction effect between the two predictors. In case of a nonsignificant interaction effect, we model the two predictors additively. All p values were two-sided, and p values smaller than 0.05 were considered statistically significant.

For the statistical analyses, we used R Version 4.1.2 (R Core Team, Vienna, Austria).

RESULTS

Study Population

We included 60,047 patients from 20 ICUs: eight university ICUs, six large nonuniversity ICUs, and six small nonuniversity ICUs. Totally 514 patients (0.85%) were admitted as PODs (0.5–18.3 per 1000 admissions across the ICUs). The frequencies of PODs admitted to each ICU for each study year are illustrated in **eFigure 2** (http://links.lww.com/CCM/H450). The overall in-hospital mortality for all years was 6,738 of 60,047 (11.2%). The etiology of the brain damage of the PODs was intracerebral hemorrhage (ICH) in 44%, trauma in 22%, subarachnoid hemorrhage in 15%, hypoxemic brain injury in 5%, ischemic stroke in 4%, and miscellaneous etiology in 10% of the cases.

After excluding PODs, the predicted number of deaths was 6324 and the actual number of deaths was 6261, indicating 63 fewer deaths were observed than predicted. However, when the PODs were included, the predicted number of deaths was 6479 but the observed number of deaths was 6738, resulting in 259 more deaths observed than predicted. The PODs had a predicted in-hospital mortality risk of 39% but the observed mortality was 93%. The deaths of PODs accounted for 7% of all deaths in the study population during the hospital stay.

We found no association between the frequency of POD admissions and calendar year (p = 0.60) or hospital size (small nonuniversity hospital, large nonuniversity hospital, or university hospital) (p = 0.44). Furthermore, there was no statistically significant difference in the median age between POD patients and non-POD patients (p = 0.05; **Table 1**).

SMRs in Cohorts With and Without PODs

The SMR without PODs was 0.99 (95% CI, 0.97–1.02) but it increased to 1.04 (95% CI, 1.01–1.06) when the PODs were included. The ratio of the SMR in the cohort without PODs to the SMR in the cohort with PODs was 0.96 (95% CI, 0.93–0.99). We found no evidence for an interaction effect between the two cohorts and hospital typology (p = 0.89). In an additive model without an interaction effect, hospital typology was strongly associated with a change in SMR (p < 0.001). Small nonuniversity hospitals showed a ratio of SMR of 1.14 (95% CI, 1.08–1.20), compared with university hospitals (**eTables 1-3**, http://links.lww.com/CCM/H450). The adjusted ratio of the SMR in the population without PODs to the SMR in the population with PODs was 0.96 (95% CI, 0.93–0.99). Calendar year-adjusted ratios comparing the SMRs of the cohort without PODs and the cohort with PODs in individual ICUs ranged from 0.92 to 1.00 (**Fig. 1**). The annual SMRs for each ICU in the cohort with and without PODs are presented in the **eFigure 3** (http://links.lww.com/CCM/H450). SMRs ranged from 0.89 to 1.51 in the cohort with PODs and 0.86 to 1.47 in the cohort without PODs. The impact of POD exclusion on the individual ICU level is illustrated in **Figure 2**.

Alterations to Benchmark Rankings

Including PODs affected ICUs' benchmarking rankings. Rankings were altered in 70% (14/20) of the ICUs by exclusion vs. inclusion of PODs (**Fig. 3**). There was no difference in mean ranking change between ICUs of large nonuniversity hospitals, small nonuniversity hospitals, and university hospitals (p = 0.45). There was a weak trend toward the improved ranking of the ICUs admitting more PODs after excluding the PODs from the whole study population (**eFig. 4**, http://links.lww.com/CCM/H450).

DISCUSSION

In this registry-based study on 60,047 ICU patients, PODs accounted for 0.9% of all patients but 7% of all in-hospital

TABLE 1.
Baseline Characteristics and Hospital Mortality

Characteristic	Admission Cause Other Than Being Potential Organ Donor, *n* = 59,533[a]	Potential Organ Donors, *n* = 514[a]	*p*[b]
Year			0.6
2015	19,321 (32%)	157 (31%)	
2016	20,034 (34%)	182 (35%)	
2017	20,178 (34%)	175 (34%)	
ICU class			0.4
Nonuniversity (large)	9,547 (16%)	77 (15%)	
Nonuniversity (small)	5,981 (10%)	60 (12%)	
University	44,005 (74%)	377 (73%)	
Age	63 (49–73)	65 (54–72)	0.053
Operative	23,486 (39%)	24 (4.7%)	< 0.001
Emergency	47,436 (80%)	513 (100%)	< 0.001
Simplified Acute Physiology Score II score	15 (7–27)	43 (39–51)	< 0.001
Hospital mortality	6,261 (11%)	477 (93%)	< 0.001
Acute Physiology and Chronic Health Evaluation-III diagnosis group			
Nonoperative: Cardiovascular	8,599 (14%)	20 (3.9%)	
Nonoperative: Respiratory	6,012 (10%)	2 (0.4%)	
Nonoperative: Gastrointestinal	3,150 (5.3%)	0 (0%)	
Nonoperative: Neurologic	9,664 (16%)	346 (67%)	
Nonoperative: Trauma	3,708 (6.2%)	104 (20%)	
Nonoperative: Metabolic	2,392 (4.0%)	0 (0%)	
Nonoperative: Hematologic diseases	214 (0.4%)	0 (0%)	
Nonoperative: Renal	700 (1.2%)	0 (0%)	
Nonoperative: Other	1,749 (2.9%)	16 (3.1%)	
Operative: Cardiovascular	4,606 (7.7%)	2 (0.4%)	
Operative: Respiratory	1,685 (2.8%)	0 (0%)	
Operative: Gastrointestinal	6,730 (11%)	0 (0%)	
Operative: Neurologic	7,261 (12%)	15 (2.9%)	
Operative: Trauma	1,421 (2.4%)	9 (1.8%)	
Operative: Urology/gynecology	1,101 (1.8%)	0 (0%)	
Operative: Other	541 (0.9%)	0 (0%)	

[a]*n* (%), median (interquartile range).
[b]Pearson's χ^2 test.
"Operative" means being admitted to the ICU from operation theater after surgery; "Emergency" means an unscheduled ICU admission for an acute reason.

deaths of ICU patients. PODs had a statistically significant impact on SMRs: excluding PODs decreased the SMR in the whole population. The effect was consistent over the 3 study years and ICU categories. SMR-based ranking positions changed for 70% of the ICUs after POD exclusion.

If PODs are carefully selected, their in-hospital mortality will be close to 100%. This was the case in our study, whereas the predicted risk of death was substantially lower. As a result, this patient group has an erroneously high SMR. This discrepancy explains

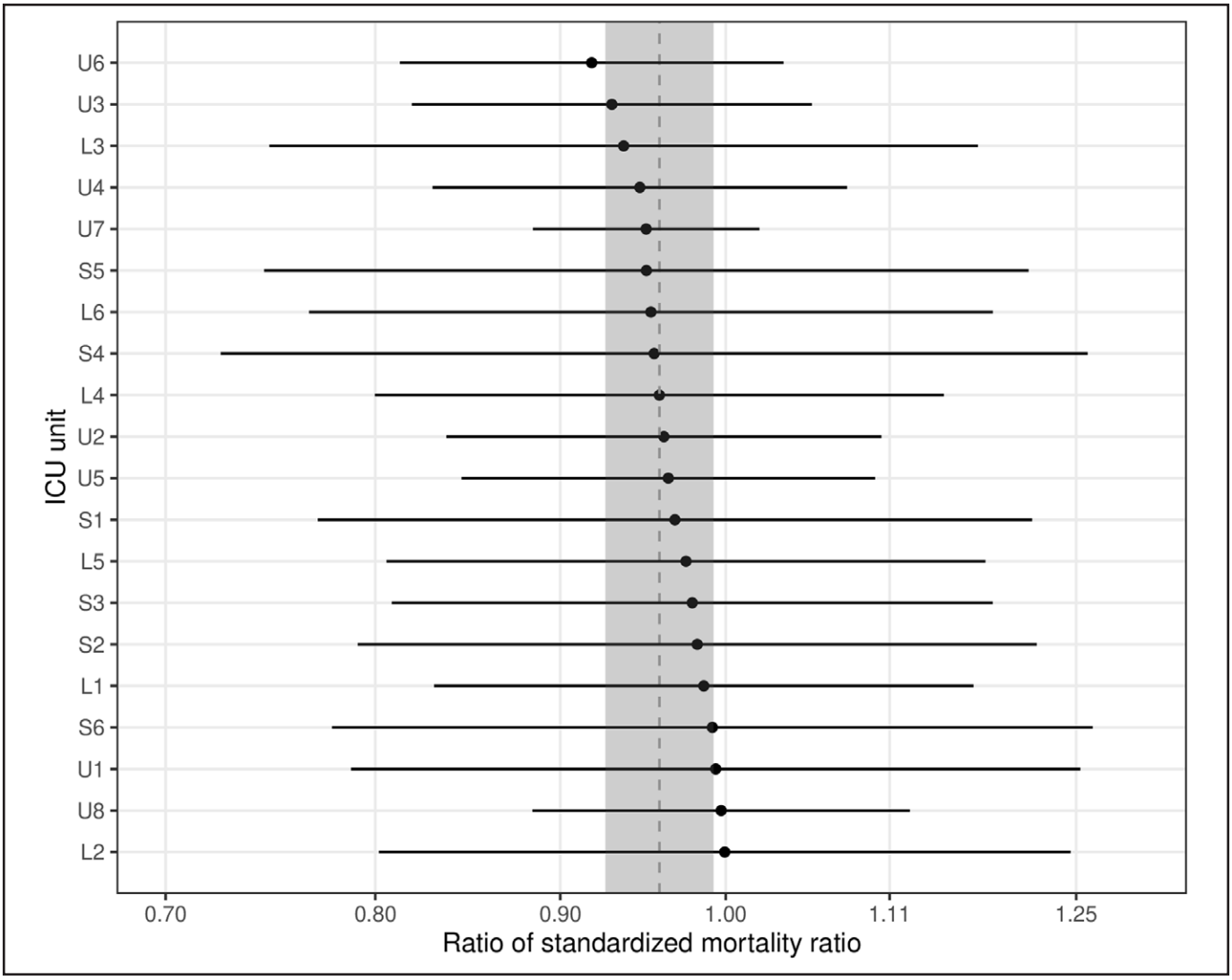

Figure 1. Ratios of standardized mortality ratios (SMRs) comparing the cohort without potential organ donors (PODs) to the cohort with PODs ($SMR_{POD\ excluded}/SMR_{POD\ included}$) in each ICU during the entire study period. The *error bars* represent the 95% CIs. The *vertical dashed line* represents the average ratio in the whole study population (0.96). The *dark gray area* represents the 95% CI (0.93–0.99).

the higher SMR in the whole cohort if PODs are not excluded. Because the common risk prediction models do not detect the true expected high risk of death in PODs, we propose that PODs should be excluded (and analyzed separately) when performing ICU benchmarking.

In benchmarking, both absolute performance and performance with respect to the other members of the consortium are important. Our risk prediction model excludes PODs due to their potential SMR confounding effects. This effect was clearly demonstrated in our study. Including PODs increased the SMR in the overall patient population, but for individual ICUs, ranking positions could change in either direction, depending on case-mix and POD admission frequency. This was caused by different magnitudes of the effect of PODs in different ICUs. Although all ICUs in our benchmark consortium treated PODs, the rate varied between one and 18 of 1000 admissions, with no differences between the three groups of hospitals. If POD treatment had been centralized in specific centers, the impact might have been much larger in these ICUs.

The current mortality prediction model is based on data from 2015 to 2017. Mortality outcomes tend to improve over time, and it is inevitable that the model needs to be recalibrated in the future. In addition to the FICC benchmarking program, the prediction model used by the Intensive Care National Audit & Research Centre takes PODs into account, by excluding PODs from the model (8).

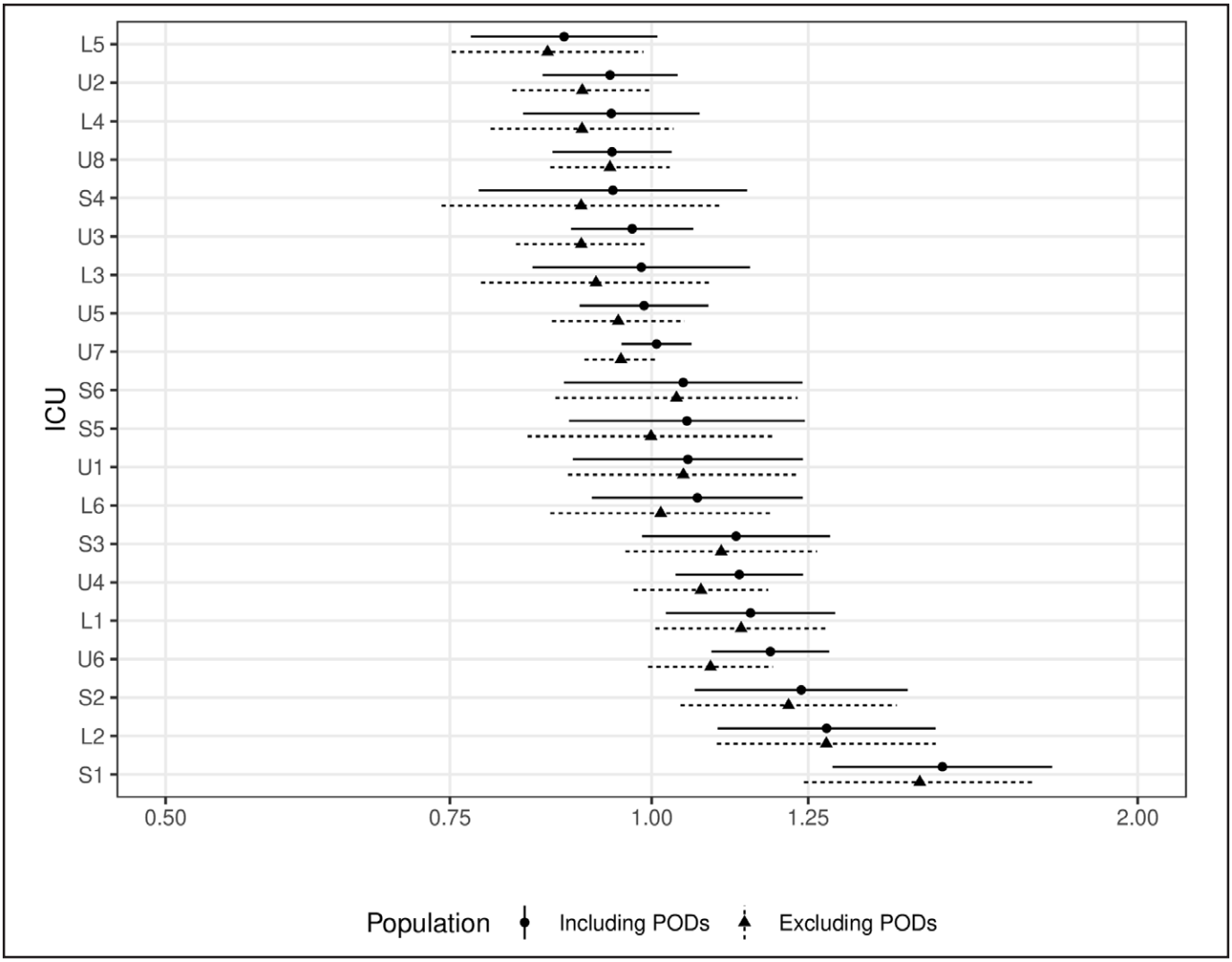

Figure 2. Impact of exclusion of potential organ donors (PODs). The *filled circles* represent the standardized mortality ratios (SMRs) of each ICU during the whole study period with PODs included. The *triangles* represent the SMRs of the ICUs with PODs excluded. The *error bars* represent the 95% CIs. The ICUs listed on the *y*-axis are arranged by increasing SMRs with PODs included. L1–L6 represent the ICUs of large nonuniversity hospitals, S1–S6 those of small nonuniversity hospitals, and U1–U8 those of university hospitals.

In the prediction model used in the current study, the only measure of neurologic condition is the Glasgow Coma Scale (GCS) score, which is included in the SAPS II score. Although the GCS score is relatively highly weighted in SAPS II, it does not alone capture the dismal prognosis associated with POD. GCS is known to be prone to interobserver variability (19). To improve the accuracy of neurologic evaluation in predictive models, it may be valuable to incorporate more objective variables, such as pupil reactivity and CT scan findings. There are several disease-specific prediction models for critically ill neurologic ICU patients, such as the International Mission for Prognosis and Analysis of Clinical Trials for traumatic brain injury patients, the Subarachnoid Hemorrhage International Trialists model for aneurysmal subarachnoid hemorrhage, and the ICH score for ICH patients (20–22). However, it is unlikely that incorporating these scores would eliminate the need for a more accurate identification of PODs for benchmarking purposes.

ICU ranking lists based on SMR should be interpreted with caution. League table rankings contain uncertainty, and random variation is high (23–25). For example, in 16 cardiothoracic centers in the Netherlands, ranking lists demonstrated considerable reordering during 3 consecutive years, but with very wide 95% CIs of adjusted mortalities (25). We also found wide and overlapping CIs in the SMRs.

The prognostic scores used in benchmarking are best suited to comparing and interpreting the risk-adjusted

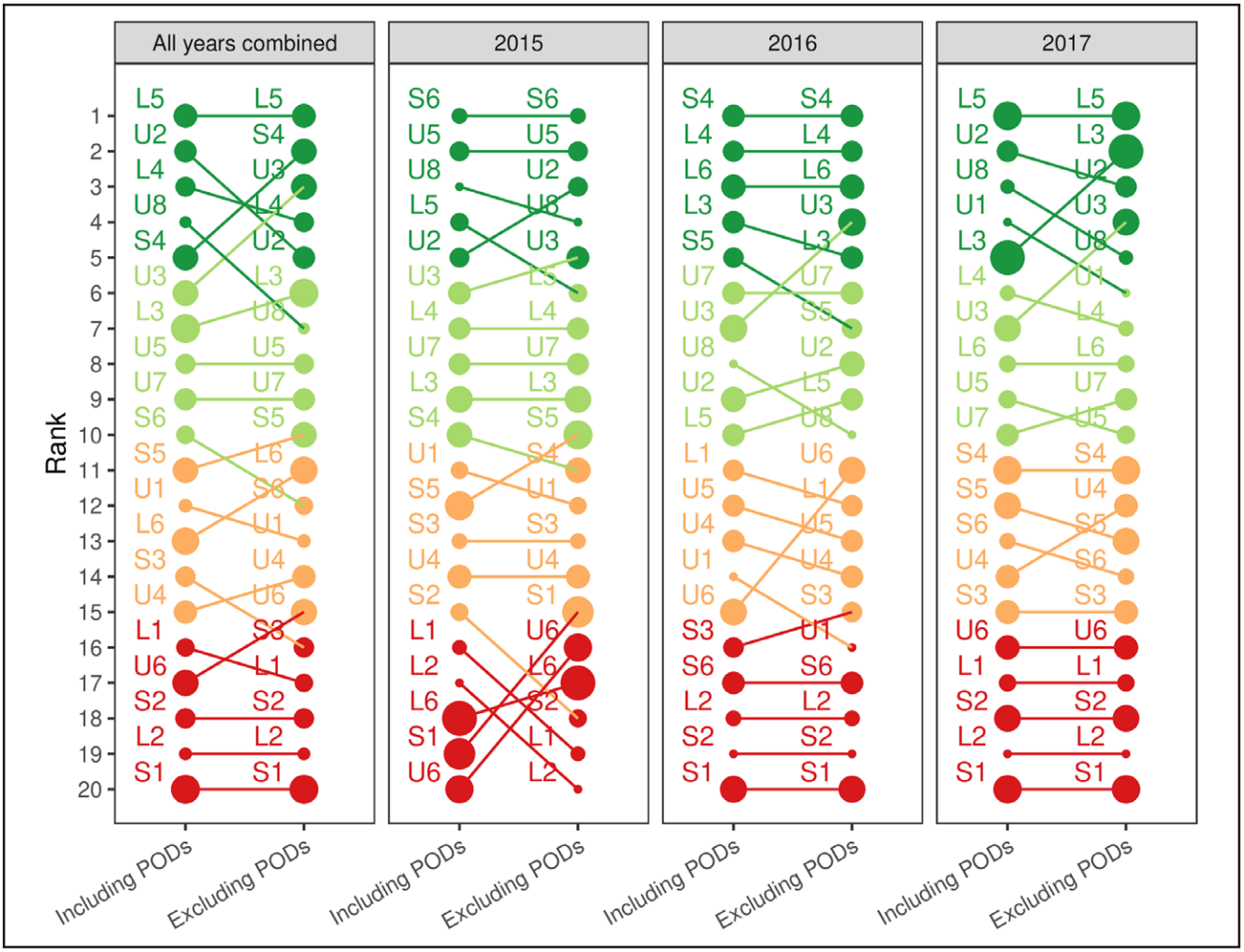

Figure 3. Alterations to standardized mortality ratio-based ranking of ICUs caused by excluding the potential organ donors (PODs) during the whole study period (*first panel*, *left*), and alterations during each study year separately (*second to fourth panel*). The *size* of the *symbol* indicates the proportion of PODs of all admissions in the ICU.

outcomes of patient groups (external benchmarking) (26). According to the European Society of Intensive Care Medicine, monitoring, reporting, and analyzing SMRs is a useful method for improving the quality and safety of intensive care (27). The effect of PODs is neglected in the prediction models of most benchmarking programs (9–12). The influence of PODs on performance quality benchmarking has not been previously investigated. The much higher observed than predicted mortality in PODs is plausible in prediction models with high weight on physiologic abnormalities. The impact of exclusion vs. inclusion of PODs on the overall mortality and the SMRs was confirmed in our study. An alternative to excluding the PODs from SMR calculations would be to create prediction models giving high expected mortality to PODs.

The need for transplantable organs is increasing worldwide (28). Compared with the patients admitted for other causes, the goal of the treatment of PODs is utterly different and their probability of in-hospital survival is extremely low. Therefore, including PODs in SMR calculations can result in wrong interpretations of an ICU's performance.

A strength of our study is that data in the FICC database were prospectively collected and validated. Second, the multinational patient cohort increases the generalizability of the results. Third, the used mortality prediction model has been validated, with good discrimination and calibration (6).

Our study has some limitations. PODs represented a very small proportion of all admissions and the annual number of PODs in individual ICUs and between the

ICUs was highly variable. Due to this variability, there were only 514 PODs out of more than 60,000 admissions during 3 years. The low number of PODs might have resulted in an underestimation of the impact of PODs on SMR. Some patients may become candidates for organ donation later during their ICU stay but this is not recorded in the FICC database. In 2015–2017, nonheart-beating organ donations were not established in the participating ICUs. Their impact on SMRs should be considered in the future. In general, benchmarking SMR is associated with several confounding variables, such as differences in admission and discharge policies (26), setting treatment limitations (13), and data completeness and sampling frequency (7). Despite the standardization of data collection, we cannot estimate the possible impact of these common confounders.

The SMR may be susceptible to differences in casemixes. In our study, the impact of PODs on the SMRs was consistent across different ICU typologies, regardless of varying SMRs. However, the study was performed in ICUs located in high-income countries. Therefore, the findings may not be generalizable to low- and middle-income countries.

CONCLUSIONS

PODs make up a small number of all ICU admissions, but their mortality is high, which is not captured by mortality risk prediction models. This causes bias in SMR calculations and consequently benchmarking results. Therefore, we propose identifying, documenting, and excluding POD admissions from SMR calculations to improve the accuracy of ICU benchmarking.

1 *Department of Anaesthesiology and Intensive Care, Kuopio University Hospital, Kuopio, Finland.*

2 *University of Eastern Finland, Kuopio, Finland.*

3 *CTU Bern, University of Bern, Bern, Switzerland.*

4 *Department of Neurosurgery, Helsinki University Hospital and University of Helsinki, Helsinki, Finland.*

5 *University of Bern, Bern, Switzerland.*

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (http://journals.lww.com/ccmjournal).

Drs. Jakob and Reinikainen contributed equally and share the senior authorship.

Dr. Pölkki was involved in writing—original draft and writing—review & editing. Dr. Moser was involved in formal analysis, software, data curation, visualization, and writing—review & editing. Drs. Raj, Takala, Bendel, and Jakob were involved in writing—review & editing. Dr. Reinikainen was involved in conceptualization, writing—review & editing, and supervision.

Dr. Pölkki was supported by institutional funding from Kuopio University Hospital, University of Eastern Finland, and The Finnish Society of Anaesthesiologists. The remaining authors have disclosed that they do not have any potential conflicts of interest.

Drs. Pölkki and Moser contributed equally and share the first authorship.

For information regarding this article, E-mail: anssi.polkki@pshyvinvointialue.fi

REFERENCES

1. Salluh JIF, Soares M, Keegan MT: Understanding intensive care unit benchmarking. *Intensive Care Med* 2017; 43:1703–1707
2. Zimmerman JE, Kramer AA, McNair DS, et al: Acute Physiology and Chronic Health Evaluation (APACHE) IV: Hospital mortality assessment for today's critically ill patients. *Crit Care Med* 2006; 34:1297–1310
3. Metnitz PG, Moreno RP, Almeida E, et al; SAPS 3 Investigators: SAPS 3--from evaluation of the patient to evaluation of the intensive care unit. Part 1: Objectives, methods and cohort description. *Intensive Care Med* 2005; 31:1336–1344
4. Moreno RP, Metnitz PG, Almeida E, et al; SAPS 3 Investigators: SAPS 3--from evaluation of the patient to evaluation of the intensive care unit. Part 2: Development of a prognostic model for hospital mortality at ICU admission. *Intensive Care Med* 2005; 31:1345–1355
5. Higgins T, Teres D, Nathanson B, et al: Updated mortality probability model - MPM0-III. *Chest* 2005; 128(4 Suppl):348S–348S
6. Moser A, Reinikainen M, Jakob SM, et al: Mortality prediction in intensive care units including premorbid functional status improved performance and internal validity. *J Clin Epidemiol* 2022; 142:230–241
7. Reinikainen M, Mussalo P, Hovilehto S, et al; Finnish Intensive Care Consortium: Association of automated data collection and data completeness with outcomes of intensive care. A new customised model for outcome prediction. *Acta Anaesthesiol Scand* 2012; 56:1114–1122
8. Harrison DA, Parry GJ, Carpenter JR, et al: A new risk prediction model for critical care: The Intensive Care National Audit & Research Centre (ICNARC) model. *Crit Care Med* 2007; 35:1091–1098
9. McClean K, Mullany D, Huckson S, et al: Identification and assessment of potentially high-mortality intensive care units using the ANZICS Centre for Outcome and Resource Evaluation clinical registry. *Crit Care Resusc* 2017; 19:230–238
10. Paul E, Bailey M, Kasza J, et al: The ANZROD model: Better benchmarking of ICU outcomes and detection of outliers. *Crit Care Resusc* 2016; 18:25–36
11. van de Klundert N, Holman R, Dongelmans DA, et al: Data resource profile: The Dutch National Intensive Care Evaluation

(NICE) registry of admissions to adult intensive care units. *Int J Epidemiol* 2015; 44:1850–1850h

12. Engerström L, Kramer AA, Nolin T, et al: Comparing time-fixed mortality prediction models and their effect on ICU performance metrics using the Simplified Acute Physiology Score 3. *Crit Care Med* 2016; 44:e1038–e1044
13. Rubio O, Arnau A, Cano S, et al: Limitation of life support techniques at admission to the intensive care unit: A multicenter prospective cohort study. *J Intensive Care* 2018; 6:24
14. Wood KE, Coursin DB: Intensivists and organ donor management. *Curr Opin Anaesthesiol* 2007; 20:97–99
15. Lytle FT, Afessa B, Keegan MT: Progression of organ failure in patients approaching brain stem death. *Am J Transplant* 2009; 9:1446–1450
16. Takala J, Moser A, Raj R, et al: Variation in severity-adjusted resource use and outcome in intensive care units. *Intensive Care Med* 2022; 48:67–77
17. Le Gall J, Lemeshow S, Saulnier F: A new Simplified Acute Physiology Score (SAPS II) based on a European/North American Multicenter Study. *JAMA* 1993; 270:2957–2963
18. Oken MM, Creech RH, Tormey DC, et al: Toxicity and response criteria of the Eastern Cooperative Oncology Group. *Am J Clin Oncol* 1982; 5:649–656
19. Reith FC, Synnot A, van den Brande R, et al: Factors influencing the reliability of the Glasgow Coma Scale: A systematic review. *Neurosurgery* 2017; 80:829–839
20. Steyerberg EW, Mushkudiani N, Perel P, et al: Predicting outcome after traumatic brain injury: Development and international validation of prognostic scores based on admission characteristics. *PLoS Med* 2008; 5:e165; discussion e165
21. Jaja BNR, Saposnik G, Lingsma HF, et al; SAHIT collaboration: Development and validation of outcome prediction models for aneurysmal subarachnoid haemorrhage: The SAHIT multinational cohort study. *BMJ* 2018; 360:j5745
22. Hemphill JC, Bonovich DC, Besmertis L, et al: The ICH score: A simple, reliable grading scale for intracerebral hemorrhage. *Stroke* 2001; 32:891–897
23. van Dishoeck AM, Looman CWN, van der Wilden-van Lier ECM, et al: Displaying random variation in comparing hospital performance. *BMJ Qual Safety* 2011; 20:651–657
24. Jacobs R, Goddard M, Smith PC: How robust are hospital ranks based on composite performance measures? *Med Care* 2005; 43:1177–1184
25. Siregar S, Groenwold RH, Jansen EK, et al: Limitations of ranking lists based on cardiac surgery mortality rates. *Circ Cardiovasc Qual Outcomes* 2012; 5:403–409
26. Kramer A, Zimmerman JE, Knaus WA: Severity of illness and predictive models in society of critical care medicine's first 50 years: A tale of concord and conflict. *Crit Care Med* 2021; 49:728–740
27. Rhodes A, Moreno RP, Azoulay E, et al; Task Force on Safety and Quality of European Society of Intensive Care Medicine (ESICM): 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 Med* 2012; 38:598–605
28. Lewis A, Koukoura A, Tsianos GI, et al: Organ donation in the US and Europe: The supply vs demand imbalance. *Transplant Rev (Orlando)* 2021; 35:100585