

LETTER

Evaluating mortality in an intensive care unit requires extended survival models

Martin Wolkewitz* and Harriet Sommer

See related research by Ju *et al.*, <http://ccforum.com/content/17/5/R230>

In a recent issue of *Critical Care*, we read with great interest that admission at nighttime is associated with poor outcomes in intensive care units (ICUs) [1]. However, Ju and colleagues showed cumulative survival plots predicting a poor survival in the ICU of less than 20% after 2,000 ICU-hours for patients for both groups (nighttime or office time) despite the fact that 148 out of 175 patients (84.6%) survived the ICU (nighttime group) and patients admitted during office time have even an ICU survival of 96.4%. These large discrepancies are very confusing for the reader. We argue that this result is subject to a common type of survival bias [2], which we explain as follows. A fundamental assumption for calculating Kaplan-Meier survival curves is that censoring is non-informative in the sense that the hazard of death remains unchanged when a censoring event occurs. Presumably, the authors treated

discharged patients as censored (displayed as crosses in their figures [1]). It is obvious that this assumption does not hold since discharged patients are usually in a better health condition than patients who stay in the ICU. This wrong assumption led to artificially reduced survival plots. The statistical solution for this is to treat discharge as a competing event for death in the ICU [2, 3] since the cumulative probability of death in the ICU depends not only on the ICU death hazard rate but also on the discharge rate.

Evaluating ICU mortality requires advanced statistical methods. Incorrect results may lead to wrong conclusions for clinicians and finally impact patient care. For that reason, it is crucial to have adequate and valid predictions for this important clinical outcome in hospital epidemiology.

Authors' response

Min-Jie Ju, Jian-Feng Luo, and Zhe Luo

We were delighted to have the opportunity to receive the advice of Wolkewitz and Sommer. Honestly, their criticism was constructive and helped us to consolidate the results of our study [1]. Hence, we might set a competing risks model to improve our analysis.

Survival analysis is a good tool when researchers take into account the time until an event occurs and the censored data. One of the common mistakes when applying survival analysis is not to include the censored data [4]. The primary outcome of our study was the ICU mortality, not the hospital mortality. The definition of 'event' was that patients died during their stay in the ICU. If the patients were alive after they were discharged from the ICU, they were censored (left-censored). We agree with Wolkewitz and Sommer that discharged patients might be in a better health condition. Therefore, we also applied survival

analysis in the propensity score matching cohort where the discharged ratio were balance distributed between nighttime and office hours (Table 1). Thus, the censoring bias was minimized and would not influence the primary result.

As for large discrepancies between the cumulative ICU survival after 2,000 ICU-hours and ICU survival probability, we think they were conceived differently. The former meant a property of any patient's survival time longer than

Table 1 Comparison of discharged ratio between nighttime and office hours admissions in 1:1 propensity score matching group

	Intensive care unit outcome		P value ^a
	Discharged (alive)	Dead	
Office hours	155	20	0.272
Nighttime	148	27	

^aChi-squared test.

* Correspondence: wolke@imbi.uni-freiburg.de
Institute of Medical Biometry and Medical Informatics, Stefan-Meier-Str. 26,
79104 Freiburg, Germany

t time, and the latter meant the ratio of the number of patients who were alive during ICU stay to the total number of patients. Accordingly, the analysis in our study had enough power to yield a credible result.

Abbreviation

ICU: Intensive care unit.

Competing interests

The authors declare that they have no competing interests.

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