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EDITORIAL

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Comparing intensive care units by size or level

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Practice makes perfect! The association between higher volumes and better outcomes is nowadays a generally accepted motivation for concentration of care. The strongest associations are found when the task or treatment is high risk or of high complexity. In trauma surgery, percutaneous coronary interventions in myocardial infarction, and many high-risk surgical procedures such a correlation between volume and outcome has been established [1]. It is very tempting to assume that such a volume–outcome relationship does exist for intensive care units (ICUs) as well, which combine both high risk and high complexity. Indeed, several studies have shown a better hospital outcome for high-volume ICUs in comparison to low-volume ICUs [2]. The question really is "is it merely volume or are other variables influencing outcome as well?"

In an article recently published in *Intensive Care Medicine* Kluge and co-workers unravel what elements of ICU care may impact outcomes for 115,909 patients from 87 Dutch ICUs covering more than 90 % of all ICUs in the Netherlands, with an emphasis on the role of volume [3]. In the Netherlands three distinct levels of care are defined: level I, level II, and level III ICUs. Apart from volume there are numerous other differences which are very likely to influence outcome (see Tables 1, 2 of the article). For example, they found that level III ICUs care for older and more severely ill patients (and, not surprisingly) have a higher hospital mortality. However, after adjustment of severity of illness, using the Acute Physiology and Chronic Health Evaluation (APACHE) IV score, differences in standardized mortality ratios (SMR) between the different levels of ICUs have disappeared (see Table 3 of the article). This suggests that the care that is provided in level III ICUs is able to "compensate" for the greater severity of illness of the patients to allow for comparable or equivalent outcomes to the other two ICU levels.

Another important confounder that might play a role is the fact that some patients are transferred from a level I ICU to a higher-level ICU—essentially a form of "regionalization"; in the analysis, this patient counts as "discharged alive" for the level I ICU and it lowers the SMR of this hospital. The researchers of this study have tried to correct for this by providing the 90-day mortality as well as by performing a sensitivity analysis that excludes transfers.

The correct way of phrasing the conclusion of this study is that "the standardized mortality ratio of level I ICUs, given their case-mix of patients, is equivalent to higher levels of ICU with their distinct case-mixes". Level III ICUs care for a larger proportion of patients

with a predicted mortality of 50–70 % and a larger proportion of patients with greater than 70 % predicted mortality than level I ICUs do (see Table 1 of the article by Kluge et al.). ICUs that care for a larger proportion of patients with high predicted mortalities often have higher SMRs. This is illustrated by a recent publication in which case-mix was artificially altered [4]. It showed that increasing the proportion of more severely ill patients has an unfavorable influence on the standardized mortality ratio. Level III ICUs care for a larger proportion of severely ill patients and thus the equivalence of SMR between different levels of ICUs could be influenced by this phenomenon.

So, let us look at more homogenous patient groups, such as patients with an out-of-hospital cardiac arrest. These patients are more likely to be equally ill and should receive the same treatment in every hospital. The 90-day mortality is no different in a level III ICU than in a level I ICU, although the confidence intervals are wide. The same is true for all the other subgroups, including pneumonia and colorectal surgery. Unfortunately, these latter groups are less homogenous than they appear at first sight. The subgroup pneumonia, for instance, is a combination group consisting of aspiration pneumonia and pneumonia due to fungal infections, viruses, or parasites and could be either hospital acquired or community acquired. Each of these pneumonias carries a distinct mortality rate and not all should be considered "being at low risk". As a consequence, comparing the 90-day SMRs in these groups is still hampered by differences in case-mix.

What elements appear to be associated with the different levels of ICU care? It is notable that higher-level ICUs were not only bigger (with greater volume), but had a higher nurse to patient ratio and a greater presence of intensivists as well. These may be key aspects that allow these level III ICUs to adequately care for sicker patients. Similar to the article by Kluge and colleagues [3], some previous publications have questioned the volume–

Table 1 Potential threats to validity of comparison of outcomes across ICUs

Potential problem	Risk	Solution
Use of unadjusted mortality data	ICUs treating more severely ill patients will have higher mortality	Adjustment of mortality data using a severity of illness model (e.g., APACHE IV)
Use of hospital administrative data	The model to correct for severity of illness is not based on standardized data, but based upon hospital administrative data that is collected and handled differently in various ICUs and between various medical specialties	Only when using vary large data sets might differences in scoring be leveled out, but still correct adjustment is difficult when ICUs do not use predefined criteria for diseases and comorbidities (i.e., a data dictionary)
Poor fit of severity of illness model	The model does not correctly fit the population of interest, i.e., in certain population groups the estimated death rate will be overestimated or underestimated	Recalibration of the model to optimally fit the population of interest
Outdated severity of illness model	The model used to correct for severity of illness no longer "fits" the ICU population. For example, the commonly used APACHE II model was introduced in 1985 and is over 30 years old. ICU medicine has evolved and new treatments have been introduced changing the outcome of patients	Use of a newer model, e.g., APACHE IV (2006). However, frequent updating of the model to the reference population (national benchmark) may be necessary (e.g., yearly recalibration)
Unvalidated severity of illness model	A model that is based upon a population of ICU patients in one country cannot necessarily be extrapolated to another system of care in another country	A model should be validated and sometimes even recalibrated to best fit the ICU population of that region/country
Use of standardized mortality ratios (SMRs)	A head-to-head comparison of SMRs ignores differences in case-mix and statistical uncertainty	Representation of SMRs in funnel plots is a better way of dealing with statistical uncertainty than hospital league tables
Outcome of hospital mortality	Some hospitals discharge their patients to "long-term care facilities" while others keep patients in the acute hospital until they die or are discharged home	Use fixed time point mortalities (e.g., 90-day mortality) rather than hospital mortality
Frequent ICU transfers	Some ICUs transfer more complex patients to higher-level ICUs. This may be recorded as "discharged alive" for the referring ICU	Use fixed time point mortalities (e.g., 90-day mortality) rather than hospital mortality
Trends over time	Funnel plots highlight the statistical uncertainty when few patients are admitted to an ICU. However, they are relatively insensitive in identifying a change in quality of care over time	Using more sensitive ways to identify a change of outcome within one ICU, like the RA-EWMA

APACHE II Acute Physiology and Chronic Health Evaluation model, version II (1985), *APACHE IV* Acute Physiology and Chronic Health Evaluation model, version IV (2006), *SMR* standardized mortality ratio (i.e., the amount of observed deaths divided by the amount of predicted deaths by a severity of illness model), *RA-EWMA* risk-adjusted exponentially weighted moving average

outcome relationship in ICUs and suggested that other organizational variables or processes might be important components of high-quality care [1]. Some of these variables were known in this study and included in the models while others remain unknown or are estimates. For instance, it is important to note that the presence of an intensivist at the ICU is derived from a quarterly inquiry and, unfortunately, not measured on a daily basis.

The comparison of outcomes across ICUs is clearly complex and the interpretation of the results is not always straight forward. There are many key factors that can influence the quality of the comparisons of outcomes that are made across hospitals (Table 1). Some of these largest threats to validity, such as the problem of accounting for patients transferred from one ICU to another, the quality of the severity of illness risk-adjustment, and reliance on hospital mortality, are all addressed in this study. The overall message is that comparing the delivery of care in ICUs is quite an endeavor; many aspects of care delivery, known and unknown, will always play a prominent role. The data presented in this study suggest that the overall care provided by all levels of ICUs in the Netherlands is excellent and that patients and appropriately staffed and organized ICUs are well matched to provide consistent outcomes across ICUs.

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