Michael D. Howell
Jennifer P. Stevens

ICUs after surgery, mortality, and the Will Rogers effect

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M. D. Howell (✉)
Center for Quality, Section of Pulmonary and Critical Care,
University of Chicago Medicine, Chicago, IL, USA
e-mail: mdh@uchicago.edu

J. P. Stevens
Division of Pulmonary, Critical Care, and Sleep Medicine,
Department of Medicine, Center for Healthcare Delivery Science,
Beth Israel Deaconess Medical Center, Boston, USA

In a recent article in *Intensive Care Medicine*, Gillies and colleagues describe and seek to explain the substantial variation in patient survival following surgery after admission to the intensive care unit (ICU) [1]. At this point, we consider it essentially settled science that health care delivery varies [2, 3], that surgical care varies [4], and that even care within a single payer health care system varies. Gillies et al.'s work echoes this theme. They found a 10 % variation in mortality across the UK among patients admitted to critical care directly from surgery, not explained by measured patient-level characteristics.

What, then, should we learn from this study?

Surgeries, ICUs, and patient flow

A core finding from the work of Gillies et al. suggests that surgical patient mortality among patients admitted directly to critical care services was explained by how hospitals used their ICU beds following surgery, not simply by whether there were ICU beds (or how many), or even by how sick the patients were. Specifically, the

number of ICU admissions per 100,000 surgical procedures better explained how mortality varied than did case mix or regional ICU bed provision.

Some hospitals have too few ICU beds for their needs. Building more ICU beds seems like an obvious solution, but Gillies' findings suggest that such a strategy will not necessarily result in lower post-surgical mortality without attention to policies about which patients go to those ICU beds. How the ICU beds are used plays an important role.

We know that patient flow to critical care services matters to patient survival. For example, when the medical ICU is full, the odds of cardiac arrest outside the ICU nearly double [5]. Delays in moving patients to the ICU from the emergency room [6, 7] and from the floor [8–13] have demonstrated harm to patients. Gillies' work extends this to the perioperative space.

If this finding is correct, there may be room to improve surgical mortality through changes in ICU allocation and, potentially more importantly, through patient flow—a powerful policy opportunity.

But what if we can't afford to build more ICU beds? Before we rush to an ICU building boom, we should note that increasing ICU capacity does not always require building new ICU beds. We know that inattention to patient flow leads to rationing without contemplation [14], and that improving flow builds capacity without building beds. We also know that tools from quality improvement, industrial improvement techniques such as Lean, and operations management have been used to successfully improve ICU capacity without capital expense [15]. More sophisticated tools such as queuing models and discrete event simulation are increasingly playing a role in ICU patient flow management [16].

In the perioperative realm, we also know that demand smoothing plays an important role. By anticipating ICU bed need following surgery and smoothing the process of entry to a higher level of care, patients may be better

served. For example, hospitals may consider closer examination of barriers to critical care entry from the surgical theater, whether those are barriers to transitioning patients to the floor, availability of staff at different times of day, or physician and physician extender coverage in the ICU. While health care delivery innovations at the hospital level have been described by Uma Kotagal and her team [17], there may be an opportunity here to deliver safer postsurgical care more broadly.

A word of caution: what would Will Rogers say?

Despite the potential policy implications of this work, however, we would offer one significant word of caution. Analysis of large delivery systems must wrestle with the often-intractable challenges of selection bias. In this case, Gillies and colleagues' work raises the specter of the Will Rogers phenomenon. This epidemiological phenomenon gets its name from the humorist Will Rogers, who reportedly said, "When the Okies left Oklahoma and moved to California, they raised the average intelligence in both states."

This phenomenon can happen whenever a group of patients moves between one category and another. For mortality, for example, it occurs whenever the group that "leaves" one category has a higher mortality than those patients who are left behind, but a lower mortality than the group they "join." The mortality rate of both groups will then artifactually decrease. We have laid out a concrete, if implausible, thought experiment in Table 1 to show how this could work. Other studies have demonstrated this phenomenon—the movement over time or between groups of patients into and out of a disease stage—among patients with lung cancer [18] and among patients moving between insurance plans [19]. It can have meaningfully large effects.

With regards to delivery of critical care services following surgery, it could be that "if you build it, they will come," and that adding more ICU beds just adds less sick patients to the ICUs, without changing overall hospital mortality. The authors' efforts to control for patient-level severity of illness in this study demonstrates their

Table 1 A thought experiment about the Will Rogers effect in a hypothetical hospital

	2014		2015	
	<i>n</i>	Mortality (%)	<i>n</i>	Mortality (%)
Went to ICU	50	20	313	16
Did not go to ICU	950	10	688	8
Total hospital	1000	10.5	1000	10.5

In this example, the hospital builds more ICU beds between 2014 and 2015. It is therefore able to move a large number of patients into the ICU who formerly went to the wards. The total number of patients at the hospital does not change, nor does the overall hospital mortality rate. But both the ICU mortality and the non-ICU mortality fall by 20 %. This is a concrete (if implausible) example of the epidemiological phenomenon known as the Will Rogers effect

understanding of the challenges of their complicated endeavor: health care delivery systems are invariably complex and drawing accurate causal inferences from large datasets represents the important and underappreciated central challenge of health care delivery science. The existing data that were collected cannot, unfortunately, address this one way or the other, because the authors did not have access to whole-hospital mortality for patients not admitted to ICU. This does not mean that Gillies' findings are incorrect, but until we have more data we should have some caution in applying them to broad policy decisions.

What should we take away from this study? Should we ignore Gillies and colleagues' findings? Absolutely not. We should conclude that not only are researchers continuing to push the bounds of the field of health care delivery science to measure and improve how we delivery care to patients but significant methodological challenges like the Will Rogers effect must be carefully studied as well. And in the meantime we should be attentive to the fact that how we use ICU beds matters, both in the medical and surgical realms.

Compliance with ethical standards

Conflicts of interest The authors have no financial conflicts related to the material in this manuscript.

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