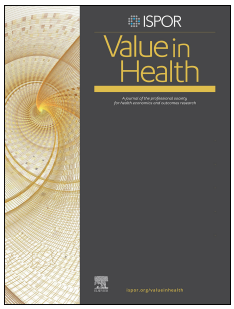

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Methodological challenges with conducting health economic evaluations in the critical care context

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Methodological Challenges With Conducting Health Economic Evaluations in the Critical Care Context

Critical care, also known as intensive care, refers to medical treatment and monitoring provided to patients with severe, life-threatening illnesses or injuries in a specialized hospital unit, typically an intensive care unit (ICU). Emerging over half a century ago, the specialty has grown into a multidisciplinary discipline facing the challenges of increased demand driven by aging populations with increasingly complex profiles of comorbidities, workforce shortages, and rapid technological advances.[1]

While ICUs represent a compelling case study, many of these same pressures extend across the hospital environment as a whole. Hospitals remain sites of both extraordinary innovation and persistent defects in value.[2] These defects are breakdowns in the design and delivery of care that compromise safety, quality, and efficiency.[3]

Despite evidence from industrialized countries that critical care costs represent a significant proportion of acute hospital budgets,[4,5] a recent systematic review of health economic evaluations conducted in the critical care context identified only 219 relevant studies published over the last 30 years, albeit with a notable spike in publications over the last decade.[6] Furthermore, the number of health economic analyses of other types applied to critical care remains sparse. This scarcity is mirrored in hospital medicine more broadly, where health economic evaluations of system-level safety and quality initiatives are rare relative to the scale of the problem.

This issue of *Value in Health* showcases two new health policy analyses, including an assessment of a physician-directed cost savings reinvestment program,[7] and a study that assesses the relationship between emergency departments and ICU nurse work environments and patient care and nurse job outcomes reported by nurses.[8] These studies point to wider lessons for hospital safety and quality beyond intensive care. As Muir et al demonstrate, misaligned work environments contribute to poor patient outcomes and nurse burnout.[8] This represents a measurement defect in value, where quality is poorly defined and operationalized. Yesantharao et al advance a physician-led reinvestment framework that addresses analytic defects in value measurement by showing how validated savings can be captured and reinvested.[7] Their approach links frontline engagement to system improvement. Together, these articles exemplify how identifying and addressing defects in value can create more resilient hospital systems.

One of the foremost challenges in conducting health economic evaluations in critical care— and in hospital medicine more broadly—is the high degree of clinical and patient heterogeneity evident in research study populations. ICUs will typically treat patients that differ vastly in their diagnoses, severity of illness, comorbidities, age, treatment responses and prognoses, and preferences where they are expressed through patients or proxies. Across hospitals, heterogeneity case-mix, comorbidities, and care processes also complicate evaluation of quality and safety initiatives.[9] From surgical appropriateness to oncology pathways, attribution of outcomes to interventions is confounded by overlapping treatments and transitions of care. These methodological

hurdles make transparent evaluation of hospital-wide reforms, such as centers of excellence or standardized protocols, both challenging and urgent.[10]

Many health economic evaluations conducted in critical care contexts are characterized by short analytical time horizons, with health outcomes often expressed in short-term mortality or morbidity metrics, often restricted to the initial ICU or hospital admission.[6] The requirement to capture differences in economic outcomes of relevance, such as health-related quality of life and mortality outcomes over the longer-term, will require either the longer-term follow-up of patients and tracking of relevant costs and consequences, or decision-analytic models that draw upon evidence from secondary sources. Both approaches carry particular challenges. Prospectively designed research studies that follow-up patients are prone to high rates of study attrition, high levels of data missingness, and lack of standardized outcomes, as well as variable reporting of key covariates.[11] Retrospective linkage of patient identifiers to electronic health records requires sophisticated data infrastructures and often faces privacy and regulatory barriers. Moreover, electronic health record systems usually lack granular information required to determine ICU costs or other hospital costs, such as staffing, high-cost medications, or different forms of mechanical ventilation.[12] They also tend to exclude patient-reported or caregiver-reported outcome measures, such as the EQ-5D health-related quality of life measure, required for cost-effectiveness-based decision making. Decision-analytic models are increasingly used as an alternative vehicle for economic evaluations in this context.[6] Dynamic simulation models, such as discrete event simulations, can go some way to reflect the complex clinic pathways typically

experienced by ICU patients. Nevertheless, they remain relatively rare in this context and this is compounded by a tendency to rely on nonsystematic approaches for evidencing parameter inputs.

There are also a number of practical obstacles to conducting health economic evaluations specific to critical care populations and settings, for example, challenges in collecting patient-reported outcomes in incapacitated patients.[13] Generic preference-based measures of health-related quality of life, such as the EQ-5D and SF-6D, display varying psychometric properties in the critical care context.[14] Beyond concerns about the validity, reliability and responsiveness of patient-reported outcome measures, patients are commonly unable to communicate their health status. Reliance on proxy reporting is common,[13] but family members themselves experience a range of intense and often distressing emotions to consider participating in research studies. This is particularly the case when patients are first admitted to critical care following an acute event such as a cardiac arrest or a serious traumatic injury. Researchers sometimes resort to delaying the time at which health-related quality of life is assessed[15] or asking surviving patients to retrospectively recall their health state prior to admission to critical care.[16] Both approaches carry biases not least because health-related quality of life assessments are restricted to survivors. A recent methodological review noted that where baseline measurement of health-related quality of life is not practical, measurement at the earliest opportunity following admission to critical care should minimize bias in quality-adjusted life year (QALY) estimation.[17] Nevertheless, further

research is needed to determine the impact of different approaches to and timing of health-related quality of life measurement on cost-effectiveness outcomes.

Approaches to cost estimation vary widely, likely driven by feasibility constraints rather than concerns for methodological rigor. The prices (unit costs) attached to resource items are often derived from national unit cost databases or institution-specific cost lists, but many studies still rely on charges as a surrogate for costs.[18] Studies that apply top-down approaches to valuing resource and cost components[19] often exclude key cost drivers from their valuation calculus. For example, economic evaluations conducted in the United Kingdom tend to rely on critical care healthcare resource groups (HRGs) to value standard resource bundles, encompassing staffing, equipment, consumables and diagnostics. High-cost drugs and interventions are excluded from these HRGs[20] and their inclusion requires a separate approach to measurement and valuation across the care pathway. Unfortunately, this is often overlooked by economic analysts, reporting journals, and end users with the potential for misleading study conclusions and suboptimal decision making.

Economic analyses of policy interventions in critical care tend to focus on system-level changes, such as modifications to ICU staffing models, triage protocols, or admission criteria. Recently, Yu and colleagues used difference-differences analysis to investigate the effects of an expanded policy to guarantee out-of-pocket costs on the treatment outcomes of patients in South Korea with tuberculosis.[21] Zheng and colleagues also used a difference-differences approach to investigate the effect of an ICU bed capacity

optimization method on the average length of stay and average cost of hospitalization within the context of an open epidemic policy in China.[22] The use of quasi-experimental methods can be extended to assess the cost-effectiveness of policy interventions. However, there are inevitably threats to the validity of the results of these studies, many of which emanate from the dynamic clinical environments in which they are implemented. Policy interventions tend to be rolled out in the context of evolving healthcare environments, where multiple changes can occur simultaneously, making it difficult to isolate the effects of the policy under study. Usual care may, indeed often does, vary across sites, making it difficult to identify a comparator that reflects standard practice and complicating the task of isolating the effects of the policy. Moreover, reliance on administrative data rather than data from prospectively designed research studies will inevitably lead to inaccuracies in the calculation of costs and the omission of outcomes of relevance to patients and decision makers.

In summary, health economic evaluations remain sparse in critical care and face a multitude of methodological challenges and data limitations, but the same applies more broadly to hospital safety and quality evaluations. Addressing these challenges requires methodological innovation, improved data collection infrastructure, and a commitment to eliminating defects in value across the continuum of care.[23] Making even incremental dents into a trillion-dollar problem of wasteful care throughout health systems can generate profound improvements in outcomes and cost efficiency. Hospitals must therefore embrace a goal of zero defects in value across ICUs, surgical suites, oncology wards, and beyond.

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