Rigor and Reproducibility in Critical Care Research
By Cindy L. Munro, RN, PhD, ANP, and Richard H. Savel, MD

How can we improve the evidence that serves as the foundation of safe and effective critical care practice? Scientists, clinicians, and the public have focused recently on problems affecting quality and trustworthiness of research in many areas of science. Ensuring rigor (adherence to high standards of research methods) and reproducibility (obtaining the same results when experiments are repeated) is crucial to all of science. However, the stakes are highest in research that ultimately affects patient care. The National Institutes of Health (NIH),1 the National Academies of Sciences, Engineering, and Medicine (NASEM),2 and the popular press3,4 have all expressed concerns about rigor and reproducibility. NIH and NASEM have proposed actions aimed at improving the design, conduct, and reporting of research. Consideration of these recommendations will improve any research project, but they are particularly applicable to clinical researchers interested in building a high-quality, trustworthy knowledge base for critical care practice.

The NIH has developed a set of guidelines that are aimed at improving rigor and reproducibility.5 The NIH guidelines took effect in January 2016, and they require research proposals to explicitly address 4 areas: scientific premise, design, consideration of relevant biological variables, and authentication of key biological and/or chemical resources. The scientific premise provides the foundation for new research; a shaky foundation undermines confidence in the new research built upon it. Although it may seem obvious that any research project should be undergirded by previous knowledge in the field, developing a scientific premise requires that researchers carefully consider both the strength and the quality of existing evidence and that they articulate how existing knowledge informs the proposed project. Stating the scientific premise is not a defense of previous research. Rather, it is an examination of the strengths and weaknesses of prior studies that informs the research questions, study design, and analysis of proposed research.

The design of a research study contributes to both rigor and reproducibility. Rigor depends on scrupulous adherence to scientific methods and to the requirements of specific research designs. Both qualitative and quantitative research have standardized approaches to enhance rigor. The NIH guidelines require investigators to explain how choices in study design and methods will lead to “robust and unbiased” results. Justifying decisions about the research plan is important for researchers in clinical settings as well. For example, is the number of study participants large enough to yield a reliable answer to the research question, and how was that number determined? Descriptions of the design and methods must
be sufficiently detailed to permit others to understand what will be (or was) done and to replicate the research.

Standardized reporting systems are excellent templates for ensuring that appropriate details of clinical research are explained. The Consolidated Standards of Reporting Trials (CONSORT) statement provides a roadmap for reporting the elements of randomized trials, and the Standards for Quality Improvement Reporting Excellence (SQUIRE) guidelines provide similar reporting structure for quality improvement projects. The EQUATOR (Enhancing the QUAlity and Transparency Of health Research) network has a library of reporting systems for qualitative and quantitative research on their website. Although designed to improve reporting of qualitative research, quantitative research, and quality improvement projects, these systems also provide a strong scaffold for project planning. Considering the reporting elements during development of the study improves the likelihood that the final report will provide information necessary for reproducibility. Standardized approaches to planning and reporting research contribute to rigor and reproducibility.

The new focus on relevant biological variables in the NIH guidelines is directly applicable to all critical care research. Sex is one biological variable that is specifically called out by the NIH guideline. Whereas past efforts have focused on increased inclusion of women as research participants, the new guidelines ask investigators to factor sex into the research design and analysis in a way that permits sex-based comparisons. The goal is to understand how sex influences underlying disease mechanisms and response to interventions. However, sex is not the only biological variable that may be crucial to critical care research. Other biological variables such as age, underlying comorbid conditions, or body mass index may be very important and are often understudied. Enhanced attention to inclusion of biological variables in study design and analysis will inform personalized care for critically ill patients.

Critical care research has some inherent checks and balances that support rigor. Requirements for protections of research participants’ rights, including review and oversight by an institutional review board, focus attention on study design and data integrity. Approval by internal research councils provides an additional level of scrutiny for study quality. Clinical data are frequently used as a source of research data, and one might argue that clinical data may be less susceptible to bias. On the other hand, reproducibility is a constant problem for critical care research. Even with stringent adherence to the study protocol, critical care environments—and critically ill patients—introduce variability into research. Some variability can be identified and controlled, but other factors, which may influence the results, are difficult to ascertain. Studies conducted in a single unit or a single institution are particularly vulnerable to these.
We should temper our enthusiasm for changing practice on the basis of results of a single study.

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FINANCIAL DISCLOSURES
None reported.

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