

**Abstract:**

Simulation-based research (SBR) is the term used to describe research in clinical care, education, or health care systems where simulation is incorporated into the study design. Simulation-based research has increased in prevalence and scope in the past decade, including a growing number of investigations in pediatric emergency medicine (PEM). The conduct of high-quality SBR is faced with a variety of challenges related to study design, sample size, analytic considerations, and the interpretation and/or extrapolation of experimental results to actual clinical care. This article will review the application of SBR to PEM, including a review of these methodological challenges; examples of published SBE studies in PEM will illustrate successful approaches to dealing with such challenges. In addition, future directions and recommendations for optimizing quality of ongoing SBE in PEM will be discussed.

**Keywords:**

pediatric emergency medicine; simulation-based research; resuscitation; cardiopulmonary resuscitation; airway management

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1522-8401

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# Simulation as a Research Tool for Pediatric Emergency Medicine

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Simulation-based research (SBR) is a term used to describe clinical, educational, or systems-based investigations where health care simulation is incorporated into the study design. It is a distinct entity separate from the use of simulation for quality improvement, training enhancement or supplementation, or problem remediation. Simulation-based research has seen rapid growth in the past decade, with predominant representation among acute care fields such as emergency medicine, critical care medicine, anesthesia, and neonatology. The fundamental advantages of using simulation during research mirror the advantages of simulation in education and quality improvement, including the ability to synthesize a controlled, consistent, safe environment for conducting experiments. Unique challenges also exist for simulation based-research, including difficulty with rigorous study design, clarity of outcome measures, and the contextualization of results into clinical care and educational platforms.

This article will summarize pertinent aspects of SBR as they apply to the field of pediatric emergency medicine (PEM). We will review how simulation can influence and be applied to study design, the identification of appropriate research questions and outcome measures, and specific methodological and analytic considerations pertinent to SBR. In addition, we will identify some of the important shortcomings in current SBR literature and

describe strategies for improving the quality of this science in the future.

## CHOOSING RELEVANT QUESTIONS IN PEM FOR SBR

Pediatric emergency medicine trainees require training opportunities to acquire the knowledge and skills to appropriately manage children with critical illness. However, pediatric resuscitation events are relatively rare and trainees often have infrequent opportunities to perform procedures on real patients. Many pediatric trainees finish their training lacking sufficient procedural proficiency and resuscitation expertise in the care of critically ill children.<sup>1</sup> The use of simulation as an educational tool provides a risk-free environment for both patients and pediatric trainees to address pertinent issues related to PEM training. Simulation-based education has been used in different aspects of pediatric emergency training, such as neonatal resuscitation, pediatric advanced life support (PALS), and procedural training (ie, airway management and cardiopulmonary resuscitation).<sup>2</sup> In addition, simulation-based training allows multidisciplinary teams to train together and learn skills of effective teamwork and crisis resource management.<sup>3</sup> With these applications in mind, SBR encompasses several different categories of research: simulation as an intervention, simulation as an assessment, simulation as an environment, and simulation as an outcome measure (Table 1).

### Simulation as an Intervention

As with all clinical and educational research, the questions to be addressed should be carefully determined. Simulation can play a number of different roles in a research environment.<sup>4</sup> The impact of simulation as an education intervention can be assessed. There is clear evidence that simulation is an effective educational intervention in a variety of contexts when compared with more traditional educational techniques.<sup>5</sup> The focus of SBR has now shifted to assess how different aspects of simulation-based training improve learning. A recent systematic review as identified some features of effective simulation-based education based on available studies.<sup>6</sup> These features include factors such as distributive practice, feedback, integration into existing curricula, clinical variation, group practice, multiple learning strategies, and repetitive practices. There is a scarcity of data documenting the cost-effectiveness or return on investment of SBR. Zendejas et al<sup>7</sup> reported that only 1.6% of SBR

**TABLE 1. Various uses of simulation in PEM research.**

Use of Simulation	Examples in PEM	Relevance
Simulation as an intervention	PEM residents (n = 115) were randomized to either standard or repetitive simulation training. <sup>34</sup>	A randomized trial examining the effectiveness of different aspects of instructional design in simulation-based training.
Simulation as an assessment	A psychometrically robust scoring metric for 16 Pediatric Advanced Life Support (PALS) scenarios was developed. <sup>16</sup>	The resulting metric can be used to assess performance of clinicians in PALS scenarios as part of simulation or in the real world.
Simulation as an environment	Twenty-four in situ simulations were performed for 3 months in a new pediatric emergency department. <sup>35</sup>	Simulation sessions used to assess a new clinical environment for latent safety threats before opening.
Simulation as an outcome measure	A randomized controlled trial to assess the efficacy of scripted debriefing on improving pediatric resuscitation knowledge and skills. <sup>36</sup>	Simulation scenarios were used to assess the effect of the debriefing intervention on performance in a simulated resuscitation.

reported comparative costs between simulation and other teaching methods, and found that no study performed a strictly designed cost-effectiveness analysis. Simulation-based education is resource intensive, and future research should attempt to justify the cost-effectiveness of using simulation in PEM training.

### Simulation as an Assessment

The emergence of competency-based medical education (CBME) has placed simulation at the forefront of discussion for medical training.<sup>8</sup> The simulated environment can be used to assess clinical competency.<sup>9</sup> Using simulation in this manner requires the thoughtful application of previously validated assessment tools and accompanying rater training. Research exploring the scope, utility, application, and psychometric properties of assessment tools designed to address core

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