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Clinical simulation in intensive care training: evidence, European models and opportunities for Portugal.

Simulación clínica en la formación en Medicina Intensiva: evidencia, modelos europeos y oportunidades para Portugal.

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Summary
Clinical simulation has become established as a fundamental pedagogical tool in medical training, with solid evidence of its impact on knowledge, technical skills, and clinical behaviors, as well as on patient outcomes. This article reviews the literature on simulation in Intensive Care Medicine, highlighting effective strategies such as deliberate practice, repeated training, structured debriefing, and in situ simulation. The situation in Portugal is analyzed, where the Intensive Care Medicine residency program lacks formal integration of simulation, in contrast to the Spanish model led by SEMICYUC and the European CoBaTrICE program, which is competency-based and assessed through the OSCE. National examples (Anesthesiology), a mapping of simulation centers, and a SWOT analysis identifying strengths, weaknesses, opportunities, and threats for its implementation are also presented. Finally, the role of Entrustable Professional Activities (EPAs) as a tool for objective and progressive evaluation is discussed. The structured integration of simulation into Portuguese training represents a strategic opportunity to improve educational quality, reduce inequalities, and strengthen the safety of critically ill patients.

Keywords.
Clinical Simulation, Intensive Care Medicine, Medical Training, Technical and Non-Technical Competencies, Entrustable Professional Activities, Patient Safety, Medical Education

Clinical simulation has become established as one of the most effective pedagogical tools in medical training. A meta-analysis that included 609 studies, with more than 35,000 participants, demonstrated that simulation significantly improves knowledge, technical skills, and clinical behaviors, with a direct impact on professional practice (1). These effects are more evident when programs incorporate deliberate practice, repeated training, structured feedback, and curriculum integration. Evidence indicates that simulation with

deliberate practice outperforms traditional clinical teaching in the acquisition of skills, with the following being fundamental to effective programs: clear objective definition, repeated training, structured debriefing, and aligned assessment (2-3).

Figure 1 shows the geographical distribution of Portuguese hospitals with intensive care units, medical schools, and healthcare simulation centers. This representation highlights the concentration in urban areas and the asymmetry in access, critical aspects for the equitable implementation of clinical simulation.

It is important to highlight that the benefits of simulation are not limited to learning. A systematic review focused on clinical outcomes identified small to moderate improvements in patients treated by professionals trained through simulation, especially in procedures such as airway management, endoscopy, and central venous catheter insertion (4). These data reinforce the relevance of simulation as a tool with translational potential for clinical practice.

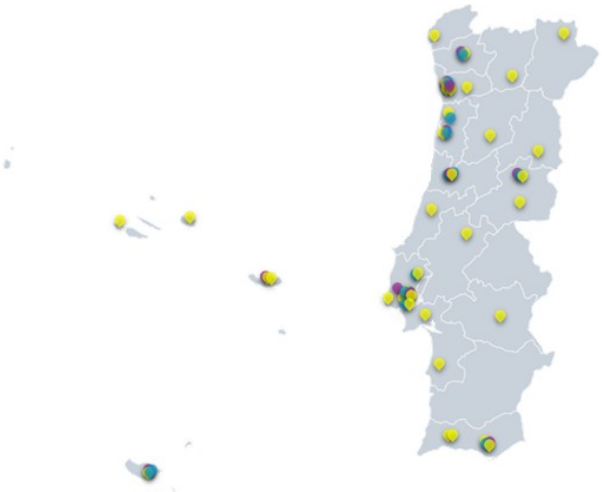

Figura 1. Geographical distribution of hospitals with ICU (yellow), medical schools (purple) and clinical simulation centers in Portugal (blue).

In Intensive Care Medicine, interprofessional simulation has demonstrated improvements in communication, teamwork, and self-efficacy, with retention at six months (5). In situ simulation, conducted in the real clinical setting, allows for contextualized training and the identification of latent failures. Studies show that this type of intervention reduces critical times in cardiac arrest and improves team performance (6). In sepsis, simulation increased adherence to the hour-1 bundle and reduced identification times (7). In mechanical ventilation, randomized clinical trials demonstrate that structured simulation-based curricula, including remote simulator training, improve performance compared to conventional teaching (8-9).

Despite this evidence, the Intensive Care Medicine residency program in Portugal, regulated by Ordinance No. 103/2016, does not formally integrate clinical simulation. This deficiency contrasts with the Spanish model. In Spain, the Spanish Society of Intensive and Critical Care Medicine and Coronary Units (SEMICYUC) leads the implementation of the European CoBaTrICE program (Competency-Based Training in Intensive Care Medicine in Europe), which is competency-based, uses an electronic portfolio, continuous formative assessment, and OSCE with simulation stations (10). Tutors receive specific training in feedback and simulation, and residents are regularly assessed based on real-world performance. Multicenter studies confirm the validity and acceptance of this model (11).

In Portugal, anesthesiology is an example of progressive integration. The Medical Simulation Section of the Portuguese Society of Anesthesiology (SPA), created in 2015,

develops educational and scientific activities, promotes technical and non-technical training, and collaborates with the Portuguese Society of Simulation Applied to Biomedical Sciences (SPSim) and national clinical simulation centers (12). The Coimbra Biomedical Simulation Center implemented a pedagogical plan for anesthesiology residents, with four modules aligned with the curriculum objectives of the College of the Specialty, including airway management, advanced monitoring, leadership, and communication (13).

At the national level, SPSim mapped 23 simulation centers, 86.9% of which were located in urban areas and 71.9% of which had academic affiliations, revealing installed capacity but also asymmetries in access (14). The Society has promoted courses for instructors, national congresses, and international collaborations, including with the European Society for Simulation in Medicine (SESAM) and Ibero-American societies.

Table 1 presents a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of the situation in Portugal, identifying strengths, weaknesses, opportunities and threats.

Table 1. SWOT analysis of the integration of clinical simulation in the Intensive Care Medicine residency in Portugal.

Strengths	**Weaknesses**
• Safe skills training. • Improving the safety of critically ill patients. • Essential training for multidisciplinary teams.	• Absence of a structured national program. • Lack of a consolidated institutional culture. • Shortage and disorganization of qualified human resources and adequate material resources.
Opportunities	**Threats**
• Adaptation of already proven models (e.g., Anesthesiology). • Mandatory training with the use of simulation coordinated by scientific societies. • Inspiration from the Spanish experience (*on-site simulation* , virtual reality, interprofessional training).	• Dependence on isolated initiatives without institutional support. • Possible cultural resistance to change. • Budgetary constraints and lack of investment in technology and training.

At the hospital level, the medical simulation program in the ICU (SIMUCI) at Vall d'Hebron Hospital (Barcelona) is an example of practical integration. It includes training in airway management, septic shock, respiratory failure, neurocritical care, and the management of sedation and delirium, with practical sessions in a controlled environment and objective-based assessment (15). This model promotes cross-disciplinary and competency-based training and is replicable in Portugal.

For objective and progressive assessment, Entrustable Professional Activities (EPAs) have been implemented internationally in Intensive Care Medicine programs, particularly in Canada and the United States (16-17). EPAs allow for the assignment of confidence levels to specific clinical

activities, facilitating decisions regarding supervision and progression. Simulation is the ideal setting for training and evaluating these activities, ensuring safety and standardization.

The scientific evidence is clear: simulation improves skills, fosters teamwork, and can translate into clinical benefits. Portugal has the necessary infrastructure, internal examples (Anesthesiology), and external models (SEMICYUC) that demonstrate its viability. The formal integration of simulation into Intensive Care Medicine residency programs, coordinated with EPAs and interprofessional training, represents a strategic opportunity to reduce inequalities, increase the quality of training, and strengthen the safety of critically ill patients.

Conclusions

- Clinical simulation is a highly effective tool for improving knowledge, technical skills, and professional behaviors in medical training. Its impact is greatest when it incorporates deliberate practice, repetition, structured feedback, and curriculum integration. Simulation not only enhances learning but can also translate into improved clinical outcomes for patients.

- There is geographical inequality in access to simulation centers, especially in Portugal, which affects training equity. In Intensive Care Medicine, simulation fosters teamwork, communication, and performance in critical situations. On-site simulation allows for the detection of latent errors and the optimization of real-world care processes. Despite the evidence, the Portuguese Intensive Care Medicine residency program does not formally integrate simulation, unlike the Spanish model.

- There are successful examples in Portugal, such as Anesthesiology, that demonstrate its applicability and benefits. The country has the necessary infrastructure, although there are disparities in resources and geographical distribution.

- Integrating a structured program based on competencies and EPAs represents a strategic opportunity to improve training and safety of critically ill patients in Portugal.

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