

Organized and Effective, the Future Organization of Critical Care

Evangelia Michail Michailidou

Anaesthesiologist-Intensivist, Nicosia Polyclinic, Lefkosia-Cyprus

ABSTRACT

Since the emergence of critical care in the twentieth century, the fundamental elements that underpin critical care systems—specifically, the provision of care for critically ill and injured patients and the preservation of life—have undergone significant evolution. The last fifty years have witnessed remarkable progress in diagnostic techniques, organ support, and treatment options within critical care, necessitating further enhancements to achieve the highest quality of personalized critical care. To elevate the quality of critical care in the future, advancements in several key areas are essential: the physical environment of the ICU; the healthcare professionals who attend to critically ill patients; the equipment and technologies utilized; the information systems and data management; and the research frameworks that influence critically ill patients and their families. With acutely and critically ill patients and their families as the primary focus, progress in these domains is anticipated to revolutionize care and improve outcomes in the years ahead.

*Corresponding author

Evangelia Michail Michailidou, Anaesthesiologist-Intensivist, Nicosia Polyclinic, Lefkosia-Cyprus.

Received: September 16, 2025; **Accepted:** October 27, 2025; **Published:** October 30, 2025

Introduction

The foundation of critical care medicine is based on organization, exemplified by Florence Nightingale, who centralized the care of the most severely ill patients in designated areas for enhanced monitoring and treatment. Over the years, the infrastructure of critical care has developed to include multidisciplinary teams, alongside a range of advanced technologies and resources. The current state of critical care is intricate and continues to present numerous challenges. The diversity of underlying conditions necessitating critical care contributes to this complexity. Although the management of critically ill patients has progressed, several obstacles persist, including the costs associated with critical care, access to and appropriate utilization of critical care beds, staffing constraints, and inconsistencies in management approaches.

Most recently, the COVID pandemic has placed a significant strain on healthcare systems overall and highlighted some of the obstacles that we continue to face in critical care despite all the technological advancements. Furthermore, the emotional environment of the intensive care unit (ICU) was on full display, and we were reminded of the vulnerability of patients and providers. This emphasizes the need to think outside the box when conceptualizing future directions for models of critical care medicine [1].

In this commentary, we present a vision, based on diverse experiences, personal opinions, and foundational prior evidence, of the organization of critical care in the years to come. As we conceive the future of critical care, the patient remains the focal point, and therefore, strategies that result in better and more personalized care for the critically ill should be implemented. For critical care to be effective in the future, there are opportunities to enhance multiple facets of critical care, including the physical ICU space, the people that care for ICU patients, ICU equipment and technologies, ICU information systems, and the systems for research in the critically ill. The ICU of the future should be designed and organized with all these facets in mind to optimize

outcomes, with emphasis on initiatives that may potentially impact pre- and post-care of the critically ill.

Physical ICU Space

The elements that constitute the physical ICU space are crucial for the care of critically ill patients, and there exist opportunities for innovative designs that could enhance patient outcomes. In the future, critically ill individuals will be treated in private ICU rooms specifically designed to optimize functionality, ensure privacy, foster healing in a compassionate environment, support infection control, enhance patient safety, and improve communication [2-4]. These individual room configurations should be adaptable to accommodate multiple patients or allow for a transition to an open space during periods of increased patient demand (e.g., during disasters and epidemics). The layout of the ICU will facilitate effective care delivery, as the arrangement of rooms will enable nurses and other healthcare professionals to maintain visibility and easy access to several patients simultaneously [5]. Patient visibility will be ensured through the use of smart glass transparent walls, doors, and windows that can be made opaque when necessary. The nursing station will be positioned at the bedside, bringing ICU staff closer to patient care. The ICU's location and design will take into account the needs of daily workflows, ensuring that proximity to the emergency department, operating rooms, blood bank, and radiology departments promotes efficient and safe patient transfers [6].

The rooms will mimic home environments, featuring décor, furnishings, and natural light to reduce the risk of delirium, with windows designed to showcase or simulate a healing natural scene or garden [7, 8]. Noise levels will be maintained at those typical of a bedroom, and exposure to natural light will help preserve the diurnal rhythm and prevent delirium [9]. Patients and caregivers will have control over their surroundings, including the ability to adjust the bed to face the window, manage light and temperature levels, access entertainment and educational materials, and connect virtually with family.

The multifunctional ICU beds will merge the comfort of home with the essential functionality needed for patient care. The early rehabilitation of ICU patients will be ensured through the provision of a specialized gymnastic facility. Various types of step-down or intermediate care facilities will be located near the ICU. A long-term acute care facility will cater to patients requiring extended weaning, primarily overseen by physician assistants. Monitoring systems that are ceiling or wall-mounted will facilitate mobility and provide easy access to patients in emergency situations.

The design and accessibility of the ICU will promote the unrestricted presence of family members, who will be regarded not merely as visitors but as vital participants in the healing process. Accommodations for family stays will be readily accessible and tailored to address the needs of families experiencing stress. Family members and care providers may connect virtually through the use of cameras and holographic systems [10]. Each ICU will feature a staff lounge and amenities to foster wellness, education, and productivity.

Extending ICU Care Beyond its Physical Boundaries

The future of critical care will extend beyond the confines of an ICU [11]. Policymakers, healthcare administrators, and clinical teams both within and outside of ICUs will collaborate to enable pre-hospital critical care treatment in home settings and ambulances, as well as to ensure early detection and swift response to patient deterioration in emergency rooms and general wards [12,13]. Consequently, critical care will no longer be restricted to the ICU environment, as numerous patients in wards will be monitored through wearable devices, allowing the hospital to function as a large ICU with tailored levels of care intensity. Every ICU clinician must recognize the high incidence of potentially life-altering post-intensive care syndrome, which adversely affects the physical, cognitive, and mental health of ICU survivors [14].

Post-ICU follow-up will include comprehensive medical care, physical therapy, and psychological and emotional support as part of the ongoing post-ICU care continuum. Additionally, support for family members at high risk of physical exhaustion, post-traumatic stress disorder, anxiety, and depression will become standard practice [15].

Individuals Caring for ICU Patients

It is anticipated that the intensivists workforce will decrease in the coming years, which will necessitate a stronger emphasis on interprofessional care models [16]. The current and future best practices for critically ill patients demand a coordinated, team-oriented, multidisciplinary approach that includes specialized medical and nursing personnel, along with allied health professionals such as dietitians, pharmacists, physical and occupational therapists, speech therapists, and social workers. New evidence suggests that early mobilization of mechanically ventilated patients can help reduce ICU-acquired weakness and increase the number of days free from ventilation, as well as improve the rate of discharge to home. This will require a heightened focus on patients who are more alert and mobile, supported by dedicated physiotherapy-led mobility teams that specialize in early rehabilitation for critically ill individuals [17].

Traditionally, the ICU team has concentrated on patients who are physically present in the ICU. Nevertheless, there is a growing demand for ICU services throughout the entire hospital, with rapid response teams and 24-hour in-hospital medical specialist staffing models becoming standard in numerous institutions. Community

expectations, advancements in technology, an aging population, co-morbidities, and frailty have all contributed to the heightened demand for ICU services. A significant focus will be placed on the early identification and management of critical illnesses.

Due to the attrition of the ICU workforce, which includes physicians and other professionals, maintaining a sustainable workforce for the future will necessitate a greater emphasis on staff health and welfare to alleviate burnout [18]. Additionally, it will require the implementation of staffing models that align with evolving societal attitudes towards the working environment, such as flexible working hours, training requirements, job-sharing, workload distribution, and diversity, including increased female representation among medical specialists [19]. We must continue to transition from the hierarchical structure of medical teams to a more collaborative environment. Alongside traditional training, team-based learning through simulation will enhance the synergy of the ICU team. The role of administrative leadership in collaboration with frontline staff to establish a vision and strategy in this regard will be critically important [20].

Elements discussed in other parts of this commentary will also impact the ICU workforce, and future ICU clinicians will need to be skilled in adopting digital and technological advancements, data science, and artificial intelligence.

There is a growing acknowledgment that families are essential in the ICU, not just for daily patient management during acute illnesses but also for end-of-life care [21]. The advantages of promoting meaningful involvement encompass emotional and spiritual support for both patients and families, informed clinical decision-making that aligns with the patient's beliefs and desires, and aid during the recovery phase, especially after ICU discharge. This will require ICU team members to develop communication skills not only with their peers but also with patients and their families. Creating compassionate, empathetic, and ethically as well as culturally aware clinicians who can withstand the numerous challenges of caring for critically ill and dying patients necessitates inter-professional training programs that go beyond merely teaching core ICU management skills, ensuring that holistic, patient-centered, personalized care remains the priority.

Equipment in the ICU

The physical and professional dimensions of critical care have traditionally been shaped by the equipment utilized to assist patients and their failing organs. Technological advancements are set to bring significant transformations in the equipment found in the ICU. Bedside monitors may enable direct observation of patient conditions (including vital signs, electrolytes, gas exchange, and hemodynamics) based on physiological data from wireless and wearable sensors, with most parameters being measured non-invasively, thereby minimizing the need for phlebotomy. For instance, (a) real-time arterial pressure waveforms can be obtained from either the radial artery or the carotid artery utilizing the volume clamp technique or applanation tonometry [22,23]. This method has the capability to assess ventricular dysfunction and fluid overload through pulse contour analysis; and (b) with the use of multimodal probes and sensors, hemodynamic monitoring can extend beyond merely global physiological parameters to encompass regional perfusion (such as sublingual microcirculation and cerebral perfusion) and oxygenation, as well as metabolic monitoring (including electrolytes and lactate in skin fluid).

Emerging devices for organ support will arise from the advancement of current technologies and innovative approaches to assist failing organs, including the brain. Mechanical ventilators, although significantly smaller, can provide critical physiological parameters essential for understanding ventilator-induced lung injury, such as the asynchrony index, transpulmonary pressure, mechanical power, and the degree of lung inhomogeneity [24,25]. Progress in bioengineering will transform blood purification methods. This encompasses wearable artificial kidneys that facilitate continuous dialysis, necessitating sufficient vascular access, an antithrombogenic circuit with minimal priming volume, a compact dialyzer, and remote control capabilities, as well as a bioartificial kidney implant featuring a hemofilter composed of silicon semiconductor membranes that eliminate waste products from the blood, alongside a bioreactor containing renal tubule cells that manage water volume, electrolyte balance, and other metabolic functions [26,27]. Furthermore, extracorporeal magnetic separation-based blood purification will enhance the removal of water and solutes, allowing for the swift and selective extraction of disease-causing substances from whole blood [28].

It is perhaps most crucial that traditional biochemistry will be supplanted by point-of-care devices that utilize the integration of gene expression protein biomarkers and metabolites to deliver more personalized critical care.

Point-of-care testing will identify the pertinent biomarkers, including the immune state, endothelial function, and coagulation system, to endotype individual patients in real time, thereby optimizing treatments such as antibiotics, vasopressors, and immunotherapies.

Repeated measurements of these biomarkers will indicate how treatment should be escalated or de-escalated and how the risk of liver and kidney function deterioration may arise [29].

All drug concentrations will be assessed using microfluidic devices, which will be linked to infusion pumps to modify the administered drug dosage.

As innovative devices and equipment for ICU use are developed, it will be essential to explore methods to maintain cost-effective critical care and ensure accessibility.

The Foundational Systems of ICU Care

In the coming 25 years, advancements in health information technology will be significantly greater, more accessible, and widely implemented, even in current low- and middle-income nations. Although electronic medical record (EMR) systems are expected to become standard, the anticipated reductions in mortality, length of hospital stays, and costs have not yet been realized [30]. To fully harness their potential advantages, a collaborative approach in value-driven design involving ICU clinicians and systems engineers is essential. Firstly, EMR systems will reduce the time healthcare professionals spend on documentation—which is not the case at present—by concentrating on critical data fields and facilitating automatic data collection. Secondly, solutions for medical device integration will align data from various clinical devices and monitors with the EMRs, thereby promoting efficient and precise data transfer while eliminating the multitude of devices and systems that require integration. Thirdly, prioritizing cybersecurity is crucial, particularly as geopolitical situations become more intricate and cyber-terrorists evolve in sophistication over time. Fourthly, the ability to easily retrieve and analyze data from EMRs for purposes such as audits,

benchmarking, quality enhancement, and research is vital [31]. Lastly, the implementation of artificial intelligence and machine learning will enable the forecasting of clinical trends and offer real-time decision-making support [32].

The policies governing both administrative and clinical aspects of the future ICU should be supported by established protocols. However, it is important to note that simply having protocols or a large number of them has not been linked to staff compliance or improved patient outcomes [33]. Therefore, several essential qualities are required for protocols to be effective. Firstly, they should be grounded in robust evidence, such as protocols for ventilator weaning, patient sedation, sepsis management, and pandemic preparedness [34-36]. Secondly, comprehensive strategies to enhance adherence to these protocols are necessary, which include designing steps that maximize usability and educating staff on the underlying science of these procedures. Thirdly, ICU teams must acknowledge the inherent inflexibility of protocols and permit some degree of clinician discretion in the forthcoming era of personalized medicine.

Research in Critical Care Medicine

Evidence derived from research will remain pivotal in enhancing our comprehension of critical illness and in shaping the organization and provision of high-quality critical care in the next 25 years and beyond. Defining what constitutes quality critical care through research will continue to evolve, expanding its focus beyond merely the effectiveness of care to also encompass the significance of humane treatment (care delivered with respect and dignity) and equitable access to care (care that is accessible to all)—both of which are crucial broader aspects of high-quality critical care. Assessing all these factors will broaden the traditional scope of our research and further guide treatment for individual patients. Expanding the research scope into critical illness and its related care will enhance our understanding of the entire journey of critical illness for individuals—beginning and concluding within the community. Ongoing assessment of patients throughout this journey will inevitably include both their vulnerability to and complete recovery from critical illness, thereby broadening our focus on patient-centered outcomes that extend beyond mere mortality. The exploration of susceptibility to critical illness will highlight the significant and emerging contributions of omics (such as genomics, epigenomics, transcriptomics, proteomics, and metabolomics) to our knowledge—each of these fields potentially providing insights into biological processes in ways that were previously unimaginable. Employing omics to better identify more homogeneous groups of critically ill patients within our extensive syndromic classifications, with test results available in a timely manner for research involvement, will improve patient selection. This prognostic enrichment will facilitate the identification of specific phenotypes that may respond favorably to targeted interventions, thereby increasing the likelihood of discovering therapies that could yield improved outcomes, as opposed to the current situation of negative trials conducted among heterogeneous patient populations. Furthermore, technological advancements will offer enhanced tools for hemodynamic and ventilation strategies, leading to more standardized interventions that can be effectively utilized or tested in clinical trials.

While randomized clinical trials will continue to be the cornerstone for evaluation, there will be an increasing necessity for other rigorous, mixed methods approaches (both quantitative and qualitative) to ensure a comprehensive assessment of the organization and delivery of care for critically ill patients.

The perspectives of patients and the public are expected to become more pronounced with greater active participation and engagement. Consequently, researchers in critical care will progressively adopt patient-centered outcomes, shifting the focus away from mere survival and physiological impairment towards prioritizing outcomes such as functional status and quality of life.

Regarding randomized clinical trials (RCTs), the advancement of platforms that evaluate multiple interventions simultaneously, along with adaptive design and analysis approaches, will further integrate research in critical care into clinical practice and support the development of learning healthcare systems [37]. These research platforms will also enable a smooth transition from phase II to phase III RCTs, thereby enhancing the evaluation pipeline.

The utilization of available data will become more efficient, continuing to provide the necessary infrastructure for research on critical illness. With the broader implementation of digital platforms (such as electronic health records and clinical information systems) throughout healthcare systems, along with improvements in the accuracy of data capture (ensuring completeness, validity, and reliability), the extent of manual data collection will diminish, reducing the burden and costs associated with conducting research.

Furthermore, the wider adoption of individual patient identifiers within healthcare systems, coupled with appropriate governance, will enhance the capability to link data across databases for the same patient, thereby facilitating the research required to comprehend the complete trajectory of critical illness. Transparent, open, and secure access to linked, accurate data will promote exploration and the potential for improved learning from machines, such as artificial intelligence [37].

Regional and national research networks have served as the foundation for critical care research. During the recent COVID-19 pandemic, the emergence of global research networks and platforms has taken place. The model of global collaboration, which encompasses both high- and low-resourced environments, has the potential to enhance equality, diversity, and inclusion for both researchers and research participants-focusing on conducting research in areas of greatest need. Preventing exploitative research practices, where researchers from high-income countries fail to adequately recognize their local partners and collaborators from lesser-known or resourced settings, is a crucial step towards achieving equality. This consideration should extend beyond proper authorship to include the prioritization of pertinent local research questions, along with their corresponding funding, and the enhancement of local research capacity, which involves participation from the study's conception, execution, data interpretation, and writing. However, the challenges of ensuring that all voices are heard and all researchers are acknowledged must be addressed, as well as the existing incentives for research advancement. Discovering new methods to recognize and assess the impact of research, while continuing to shift away from traditional authorship and grant-holding, will be vital for the global democratization of critical care research, as will the provision of free, open-access opportunities for the dissemination of research evidence.

Conclusion

Although critical care has seen remarkable advancements over the years, the considerable diversity of critical care conditions has posed challenges in making adequate progress regarding therapeutics. For continued advancement, the critical care infrastructure must

undergo transformation, and the emphasis should shift towards enhancing personalized medicine. Technological advancements will persist, equipping us with the necessary tools to redesign critical care management processes. It is crucial to change the paradigm and create care models that extend the treatment of critically ill patients beyond the confines of the ICU. While global differences in various aspects of critical care will always exist, striving towards this envisioned future for critical care organization will result in improved quality of care across different systems and regions, fostering a more humanistic and personalized approach with reduced errors and enhanced quality, as the ultimate aim will always be to deliver the highest standard of patient care and outcomes.

References

1. Maslove DM, Tang B, Shankar-Hari M (2022) Redefining critical illness. *Nat Med* 28: 1141-1148.
2. Halpern NA (2014) Innovative designs for the smart ICU: part 2: the ICU. *Chest* 145: 646-658.
3. Sundberg F, Fridh I, Lindahl B, Kareholt I (2021) Associations between healthcare environment design and adverse events in intensive care unit. *Nurs Crit Care* 26: 86-93.
4. Caruso P, Guardian L, Tiengo T, Dos Santos LS, Junior PM (2014) ICU architectural design affects the delirium prevalence: a comparison between single-bed and multibed rooms. *Crit Care Med* 42: 2204-2210.
5. Lu Y, Ossmann MM, Leaf DE, Factor PH (2014) Patient visibility and ICU mortality: a conceptual replication. *HERD* 7: 92-103.
6. Thompson DR, Hamilton DK, Cadenhead CD (2012) Guidelines for intensive care unit design. *Crit Care Med* 40: 1586-600
7. Sundberg F, Fridh I, Lindahl B, Kareholt I (2021) Visitor's experiences of an evidence-based designed healthcare environment in an intensive care unit. *HERD* 14: 178-191.
8. Verderber S, Gray S, Suresh-Kumar S, Kercz D, Parshuram C (2021) Intensive care unit built environments: a comprehensive literature review (2005-2020). *HERD* 14: 368-415.
9. Luetz A, Grunow JJ, Morgeli R (2019) Innovative ICU solutions to prevent and reduce delirium and post-intensive care unit syndrome. *Semin Respir Crit Care Med* 40: 673-686.
10. Hillman K (2002) Critical care without walls. *Curr Opin Crit Care* 8: 594-599.
11. Seymour CW, Rea TD, Kahn JM, Walkey AJ, Yealy DM, et al. (2012) Severe sepsis in pre-hospital emergency care: analysis of incidence, care, and outcome. *Am J Respir Crit Care Med* 186: 1264-1271.
12. Maharaj R, Raffaele I, Wendon J (2015) Rapid response systems: a systematic review and meta-analysis. *Crit Care* 19: 254.
13. Needham DM, Davidson J, Cohen H (2012) Improving long-term outcomes after discharge from intensive care unit: report from a stakeholders' conference. *Crit Care Med* 40: 502-509.
14. Azoulay E, Resche-Rigon M, Megarbane B (2022) Association of COVID-19 acute respiratory distress syndrome with symptoms of posttraumatic stress disorder in family members after ICU discharge. *JAMA* 327: 1042-1050.
15. Angus DC, Kelley MA, Schmitz RJ (2000) Caring for the critically ill patient. Current and projected workforce requirements for care of the critically ill and patients with pulmonary disease: can we meet the requirements of an aging population? *JAMA* 284: 2762-2770
16. Zhang L, Hu W, Cai Z (2019) Early mobilization of critically ill patients in the intensive care unit: a systematic review and

- meta-analysis. PLoS One 14: e0223185.
17. Kerlin MP, McPeake J, Mikkelsen ME (2020) Burnout and joy in the profession of critical care medicine. *Crit Care* 24: 98.
 18. Venkatesh B, Mehta S, Angus DC (2018) Women in intensive care study: a preliminary assessment of international data on female representation in the ICU physician workforce, leadership and academic positions. *Crit Care* 22: 211.
 19. Roy K, Brunet F (2005) The role of leadership in overcoming staff turnover in critical care. *Crit Care* 9: 422-423
 20. Burns KEA, Misak C, Herridge M (2018) Patient and family engagement in the ICU. Untapped opportunities and underrecognized challenges. *Am J Respir Crit Care Med* 198: 310-319.
 21. Michard F (2016) Hemodynamic monitoring in the era of digital health. *Ann Intensive Care* 6: 15.
 22. Michard F, Pinsky MR, Vincent JL (2017) Intensive care medicine in 2050: NEWS for hemodynamic monitoring. *Intensive Care Med* 43: 440-442.
 23. Kacmarek RM (2011) The mechanical ventilator: past, present, and future. *Respir Care* 56: 1170-1180.
 24. Gattinoni L, Marini JJ, Collino F (2017) The future of mechanical ventilation: lessons from the present and the past. *Crit Care* 21: 183.
 25. Chan CT, Covic A, Craig JC (2013) Novel techniques and innovation in blood purification: a clinical update from kidney disease: improving global outcomes. *Kidney Int* 83: 359-371.
 26. David Kindy (2021) This bioartificial organ could one day save 'millions' living with kidney disorders <https://www.smithsonianmag.com/smart-news/this-bioartificial-organ-could-one-day-save-millions-suffering-kidney-disorders-180978721/>.
 27. Herrmann IK, Schlegel AA, Graf R, Stark WJ, Beck-Schimmer B (2015) Magnetic separation-based blood purification: a promising new approach for the removal of disease-causing compounds? *J Nanobiotechnology* 13:49.
 28. Sweeney TE, Liesenfeld O, Wacker J (2021) Validation of inflammopathic, adaptive, and coagulopathic sepsis endotypes in coronavirus disease 2019. *Crit Care Med* 49: e170-178.
 29. Thompson G, O'Horo JC, Pickering BW, Herasevich V (2015) Impact of the electronic medical record on mortality, length of stay, and cost in the hospital and ICU: a systematic review and metaanalysis. *Crit Care Med* 43: 1276-1282.
 30. Higgins TL, Freese-Freeman L, Stark MM, Henson KN (2022) Benchmarking inpatient mortality using electronic medical record data: a retrospective, multicenter analytical observational study. *Crit Care Med* 50: 543-53.
 31. Martin GS (2019) The intersection of big data, artificial intelligence, precision and predictive medicine to create the future of critical care. *ICU Manag Pract* 19: 228-231.
 32. Sevransky JE, Checkley W, Herrera P (2015) Protocols and hospital mortality in critically ill patients: the united states critical illness and injury trials group critical illness outcomes study. *Crit Care Med* 43: 2076-2084.
 33. Pun BT, Balas MC, Barnes-Daly MA (2019) Caring for critically ill patients with the ABCDEF bundle: results of the ICU liberation collaborative in over 15,000 adults. *Crit Care Med* 47: 3-14.
 34. Levy MM, Rhodes A, Phillips GS (2014) Surviving Sepsis Campaign: association between performance metrics and outcomes in a 7.5-year study. *Intensive Care Med* 40: 1623-1633.
 35. Arabi YM, Azoulay E, Al-Dorzi HM (2021) How the COVID-19 pandemic will change the future of critical care. *Intensive Care Med* 47: 282-291.
 36. Granholm A, Alhazzani W, Derde LPG (2022) Randomised clinical trials in critical care: past, present and future. *Intensive Care Med* 48: 164-178.
 37. Yoon JH, Pinsky MR, Clermont G (2022) Artificial intelligence in critical care medicine. *Crit Care* 26: 75.

Copyright: © 2025 Evangelia Michail Michailidou. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.