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Perspective

The future of training in intensive care medicine: A European perspective

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Introduction

Intensive care medicine (ICM) is the science and art of preventing, caring for, and curing acutely ill patients. The specialty originated from the need to provide technology-centered organ support to the most fragile patients presenting with sequential and progressive organ failure.[1] Despite its genesis in Europe and extensive clinical and research achievements in the field, ICM has not been recognized as a distinct discipline in the European Union (EU). This has a negative impact on the free movement of intensivists across Europe. In fact, it has been a major obstacle for knowledge and competence sharing, communication, and professional interweaving across borders — all of which are crucial requirements, especially when contending with pandemics and disasters. In November 2020, the European Society of Intensive Care Medicine (ESICM) submitted a consultation paper to the European Commission proposing the inclusion of ICM in Annex V of Directive 2005/36/EC. This initiative aims to redress the current situation by conferring formal recognition to ICM as a distinct profession.[2]

A major step toward the recognition of ICM across European institutions and structures is the homogeneity and further improvement of training. Although important advances have been achieved during the last two decades, specialist critical care training varies considerably among EU countries in fundamental areas, such as length of course, quality of studies, and type of final accreditation. This reflects the different health and educational policies across Europe (Table 1).[3–5] The marked heterogeneity in training programs across Europe has been confirmed through the Competency-Based Training in Intensive Care Medicine in Europe (CoBaTrICE) project.[6] In addition, cooperation among different medical specialties in the critical care setting, multiple different contexts of intensive care unit (ICU) function, workload, discrimination, economic restrictions and inequalities, and specific problems (e.g., a progressively aging population, antibiotic resistance, etc.) represent challenges to effectual training. These obstacles invariably result in significant differences in the quality, safety, and effectiveness of care.[3,6] Moreover, following the outbreak of SARS-CoV-2 in early 2020, the need for fast-track training and international intra-disciplinary and interdisciplinary teamwork and networking skills is now, more than ever, evident to attain excellence in ICM care, with respect to survival and quality of life, in concordance with individual or societal goals.

In the present review, we aimed to outline initiatives taken to formally reorganize the ICM training framework, to address new developments and technologies, and to point out potential obstacles in critical care training.

Obstacles in Training in ICM

Inhomogeneity in curricula

Free movement of professionals is central to EU's philosophy. The EU's directive on recognition of professional qualifications implies automatic recognition of basic medical qualifications and several medical specialties.[7] To date, ICM has not been recognized as a primary specialty within the European directive on recognition of professional qualifications. A tenth of European countries have adopted ICM as a primary specialty.[5] Of the 27 EU member states, only Spain, Switzerland, and Portugal recognize ICM as a primary specialty. Elsewhere in Europe, intensivists emerge from a widely diverse subspecialty or supraspecialty backgrounds. On this basis, ICM cannot be included in the list of disciplines with automatic recognition. For ICM to be automatically recognized as a primary specialty, a two-fifth

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Table 1
Variation in ICM training programs across Europe.

Training programs		Countries
Access to ICM training	Primary specialty	Spain*
		Switzerland
		United Kingdom†
	Supra-specialty	16/33
	Subspecialty	Single 13/33
		Multiple specialties 5/33
Educational process	Duration	Supra-specialty: 24 months (14/33)
		Subspecialty: 6–24 months (during anesthesia training [range: 36–72 months])
		Primary specialty: 32–72 months
	Educational program	CoBaTrICE: 14/33
		Formal written standards: 27/33
		External visiting program: 18/33
	Certificate	ICM as primary specialty: 6/31
		Primary specialty and ICM dual: 12/31
		Anesthesia and ICM single: 14/31
		Basic specialty single: 3/31
Examinations	EDIC as the formal examination	6/33
	EDIC-based	12/33
	Regional	1/33
	Mandatory	32/33
	Techniques	Oral examination: 25 countries
		Multiple Choice Questions: 18
		Clinical examination: 12
		Skill stations: 2
		Simulations: 1
		Case-based examinations: 1

Data presented concern 31 countries in Europe and data concerning Turkey and Israel: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Ireland, Iceland, Italy, Latvia, Lithuania, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom.
The data presented concern information adopted from references.[3–6]
* Potential for primary specialty or subspecialty from anesthesiology.
† Potential for primary specialty or joint specialties of anesthesia, emergency medicine, internal medicine, and surgery.
CoBaTrICE: Competency-Based Training in Intensive Care Medicine in Europe; ICM: Intensive care medicine.

(or greater) majority of member states and concurrent approval by a weighted majority vote (determined by the population of each country) in the European Commission is required.[8] Official recognition has been impeded by the availability of various pathways leading to intensivist specialization, most of which differ among EU countries. This diversity is evident in ICM training programs as well. Few international surveys[4,5,9] have pointed out substantial disparities in content, processes, and accreditation (Table 1). Formal national standards for postgraduate training in ICM in Europe varies considerably in terms of written standards, external visiting programs, and adoption of the European Diploma in Intensive Care (EDIC) as national examination or requirement for certification of completion of specialist training. One might argue that these variations in training explain some of the differences in patient outcomes and resource use across Europe or other continents. Moreover, this variability may set obstacles in free professional movement across European countries, which, in turn, may negatively affect the quality of care and patient safety.[3] Considering these reasons, the need to homogenize intensivist training throughout Europe should be a priority for critical care scientific societies and state policies.

Inequalities and discrimination

Disparities according to age, sex, race, or social origin may be reflected in differences in healthcare management between minority and non-minority populations. These disparities can not be explained by clinical appropriateness, need, and patient preferences; and they can be detrimental to minority patients or medical professionals and trainees.[10–13] Current and future critical care professionals and trainees should be aware that discriminatory attitudes can create a toxic, hostile environment for marginalized groups, patients, students, and co-workers.[14] The gender representation gap is a distinct inequality.[15,16] Despite female medical trainees outnumbering their male counterparts in many countries, men still outnumber women in clinical and academic leadership positions around the world,[16,17] with the percentage of women ICU physicians ranging from 10% to 30% in recent surveys.[16,17] Reasons for this gender gap may include agentic traits for success in science, the perception that women are unsuitable for handling acute situations and/or undertaking long or out-of-office hour shifts, and the notion that women cannot build successful medical careers and family lives concurrently.[18,19]

Age discrimination creates another challenge in the equal provision of critical care, especially in decisions related to end-of-life issues. Age is considered by physicians when triaging patients for ICU admission[20] or deciding the appropriate level of applied care.[21] This consideration is often based on an imbalance between the demand for critical care beds and actual availability of hospital resources — where demand usually exceeds supply. Alternatively, it may be due to or compounded by poor judgment of critically ill patients.[22,23] Decisions may vary depending on the perception of the triaging doctor regarding patient life expectancy. Despite data suggesting age as an independent risk factor for mortality,[24] some studies have found that the severity of illness, frailty, and

comorbidities, rather than age *per se*, are applicable mortality predictors.[25,26]

Interdisciplinary teamwork challenges

ICM is an interdisciplinary specialty that functions within a complex hospital service network. Intra- and inter-disciplinary teams (i.e., different attending physicians, bedside nurses, respiratory therapists, clinical pharmacists, dieticians, clinical psychologists, etc.) may have divergent perspectives, and effective teamwork and cooperation are mandatory for positive patient outcomes.[27–29] Interdisciplinary team dynamics are not stable and need careful attention. Numerous studies have demonstrated that poor collaboration and communication can lead to adverse patient outcomes and higher healthcare costs. Addressing deficits in communication has direct clinical and financial benefits.[30,31] Differences in perception of collaboration and issues affecting the team environment between ICU nurses and physicians may contribute to barriers to collaboration.[32,33] Typical causes include different rotation schemes between physicians and nurses or other disciplines, different perceptions of autonomy and satisfaction in times of crisis, and different points of interaction with patients and their families.[34]

Team coordination and effective communication among its members require clear articulation of status, needs, and objectives in an efficient and timely fashion to ensure that the team behaves, adapts, and synchronizes accordingly.[35] Shared goals, team commitment, shared sense of identity, and trust are key facilitators of building trust in the team. Establishing a climate of participative safety empowers team members — especially the younger clinicians and nurses — to contribute more actively during multidisciplinary decision-making and enable them to air their concerns or ask for support.[36,37]

Furthermore, the assessment of team performance is crucial for improving teamwork. Data suggest that ICU teams are generally poor at assessing their progress and performance in terms of coordination, suggesting that they engage in little reflexivity.[38] Regular engagement in team reflexivity (i.e., team meetings or “away days”) would provide the opportunity to critically reflect on past performance and make decisions to improve critical care. On this basis, the critical care training agenda should include methods to improve the clarity and interpretability of inter- and intra-disciplinary team communication, assess effective teamwork, and improve relationships and trust.[36]

Furthermore, improving ICM training may require research and lessons directly from the “team science” literature, access to relevant theories, and concepts that elicit a better understanding of whether and how various factors develop and influence team effectiveness.[39] This could provide an exciting new learning direction that informs participant understanding of how ICU teams function optimally.

The ICU environment: ethical dilemmas, complex communication, and burnout

ICU leaders and dedicated professionals often face ethical dilemmas, such as end-of-life issues and decisions regarding the appropriateness of care level. These issues may cause conflicts and lead to a decline in the quality of care. Effective communication, shared decision-making, and good relationships with colleagues, patients, and their families are essential for disease management.[40,41] Nevertheless, the development of communication skills is not straightforward but challenging. Some previous investigations have shown that the implementation of intensive communication systems between clinicians and family members does not guarantee a positive impact on patient outcomes in the ICU.[42,43] In this respect, more studies are warranted to assess specific communication interventions to meet the needs of a family with a relative in ICU. Furthermore, ethics training programs for residents, critical care nurses, and fellows are necessary and should be administered as part of ICU training.[44]

The ICU is characterized by a high level of work-associated stress and a high degree of emotional exhaustion that derives from various factors, including workload, administration hassles, work experience, temporary work contracts, activity in other settings outside the ICU, conflicts or lack of support felt by professionals and support services, perceived complaints among colleagues, ethical decision-making, and individual factors (e.g., age, personality traits, etc.).[45,46] ICU burnout affects the well-being and quality of professionals individually and collectively, in terms of healthcare system performance.[47] Training in collaborative decision-making and ethical deliberation on critical decisions can potentially mitigate moral distress, and health organizations can take steps to address the issue by providing clinicians with some flexibility and autonomy in scheduling to unload emotional and physical exhaustion. Adoption of adequate training and use of resources to build resilience could improve the ability of ICU clinicians to cope with the inherently stressful ICU environment.[48] This training may include conceptualization of burnout, exploration of its different forms in terms of presentation and severity, tools for diagnosis, investigation of the short- and long-term consequences, approach of cross-cultural perspectives, and assessment of the effectiveness of interventions.

Emerging infections

Antimicrobial resistance (AMR) is increasingly a challenge, especially in the ICU where even sensitive pathogens already cause additional morbidity, mortality, and hospital costs.[49] AMR requires input from various stakeholders, including state organizations, media, scientific boards, hospital administrative bodies, medical teams, and health professionals. The problem has prompted the World Health Organization to adopt the Global Action Plan on AMR, a scheme that prioritizes awareness and understanding, improved education, and training in AMR. Currently, the proportion of European ICU physicians who perceive AMR as a significant problem in their ICU is high; however, considerable variations exist. In recent surveys,[50,51] infections with multi-drug resistant bacteria were rated as major and minor problems by 24% and 36.8% of ICU physician respondents, respectively. Physicians ranked training and education for better use of antibiotics among the primary priorities of AMR management. On this basis, management of infections, appropriate use of antibiotics, and antibiotic stewardship should be among the priorities of any ICU training framework.

The COVID-19 pandemic not only impacted health-care systems but also the implementation of training curricula.[52,53] A recent global survey assessed the perceived effect of the

pandemic on clinical education and training. Most critical care physicians reported a negative impact, which was highest in the United States, East Asia, and Pacific; whereas only one-third reported a positive impact; the latter was highest in Europe, Brazil, and Central Asia. The negative impact was associated with formal didactic reductions and lower supervision of trainees and attendants. Moreover, trainees reported reassignments outside their primary fields. Furthermore, both trainees and attendants complained about diminished opportunities to perform procedures. Notably, the findings of the survey indicated communication gaps between teachers and learners due to differences in the perception of the importance of didactics, supervision, procedures, and consequences of trainee reassignment.[54] A different survey outlined the effect of contagion issues in certain fellowship programs (i.e., bronchoscopy and outpatient clinics), while some core aspects of critical care training, such as central venous and arterial line catheterizations, were enhanced.[55]

Training Agenda in ICM

ICM is a relatively young specialty, characterized by diversity, be it in Europe or other parts of the world, such as Asia, America, Australia, and Africa.[3–5] Technological advancements and the need for clinical management that can contend with the exponential growth of medical information warrant continual reassessment of medical education. Furthermore, ICU training standards should encompass equal opportunities in education and practice for all trainees. In the interests of harmonization and a coherent training schedule, national legislations across countries should be amended. Previous initiatives have identified this need and proposed a framework for both basic special training and continuing medical education (CME).

Previous initiatives in basic specialty training

The CoBaTrICE project

The marked heterogeneity in training programs across Europe was identified through the CoBaTrICE project.[6] The program is a national partnership of professional organizations and intensive care providers, supported by the ESICM and the EU through the Leonardo da Vinci program. It works in close collaboration with European medical organizations, such as the Union of European Medical Specialists (UEMS).[6,56]

The CoBaTrICE syllabus comprises the sum of the knowledge, skills, behaviors, and attitudes required for each competence in ICM (102 competencies). It is presented in 12 domains: resuscitation, diagnosis, disease management, interventions, procedures, perioperative care, comfort and recovery, end-of-life care, pediatric care, transport, recovery, safety, and management (Table 2). In 2016, the CoBaTrICE project was updated to include new competencies, reflecting the change in ICM daily practice and needs. The new competencies were ultrasonography, echocardiography, extracorporeal membrane oxygenation (ECMO), and rapid response teams.[3,6,56] The CoBaTrICE initiative provided the standards for competence-based training (CBT).

The European diploma in intensive care (EDIC)

CBT encompasses the potential for informal progress assessment and formal accreditation of training results to provide sound certification. Competencies are measurable outcomes of training and should be assessed at different levels. Knowledge, skills, and attitudes should be assessed at regular intervals in the trainee workplace (regional level of assessment), while formal certification warrants examinations undertaken on a national level. The examination process varies across countries (Table 1). Apart from general knowledge examinations, only few countries provide the opportunity for skill and attitude assessment. The EDIC seeks to standardize the education and training for quality intensive care across Europe and beyond. EDIC examinations are meticulously developed and continuously updated to create standard exit examinations, which accurately reflect clearly defined assessment goals and address the necessary skills, attitude, competencies, and knowledge required for intensive care practice. EDIC examinations are set out in two parts: Part I — the written exam and Part II — the oral/clinical case exam.[57] Among countries with mandatory examinations to certify intensivists, six countries use EDIC as their formal examination.

Skill development

Critical care ultrasonography (CCUS) has become an essential component in the evaluation and clinical management of the critically ill in everyday clinical practice. Although competency statements and international guidelines have been published to organize the training of intensivists in CCUS[58] and critical care echocardiography (CCE),[59] few European countries have managed to operationalize these guidelines into an acceptable, well-structured program for clinician training in multidisciplinary intensive care.[60,61] Furthermore, only few countries have an accreditation program in ICM echocardiography and/or CCUS.[62] However, frameworks, which could become the foundation of homogenized competency training program, are already available. Recently, an international consensus of experts commissioned by the ESICM provided a list of recommendations regarding the basic skills for “head-to-toe” ultrasonography in the intensive care setting. The recommendations cover the required skills for a basic ultrasonographic evaluation of the range of patients admitted to a mixed general-neuro ICU, including medical and surgical patients.[61] The consensus describes 74 statements (7 for brain, 20 for lung, 20 for heart, 20 for abdomen, and 7 for vascular ultrasonographic images).[63] Its suitability is such that these recommendations could serve as a core for any courses, training programs, or even evaluation regimes established by the ESICM or national training organizations to guide accreditation on ultrasonography competencies.

Continuing medical education

The growing body of medical research in the field of ICM introduces changes to clinical practice that equate to improved patient outcomes. CME satisfies the ongoing struggle to keep up with scientific advancements and technology, which can serve this need. In Europe, under the CoBaTrICE perspective, available advanced training courses do not only offer refresher courses in core aspects of PCM training but also further promote continuing educational needs. Interactive courses and workshops organized by the ESICM are offered during the annual congress and at regular intervals throughout the year.[64] Training is complemented by modular self-study, asynchronous webinars, and masterclass attendance. A range of classes, including basic physiology, mechanical ventilation, hemodynamic monitoring,

Table 2
Suggested topics for CBT in ICU.

Domain	Description	Competence summary	References
Resuscitation and initial management of the critically ill patient	Recognize, correct, and prevent further deterioration of the altered organ physiology, despite the uncertainty about the underlying diagnosis	Structured and timely approach to the recognition, assessment, and stabilization of the acutely ill patient Triage patients (timely admission to ICU, manage mass casualties)	[3–6]
Diagnosis: assessment, investigation, monitoring, and data interpretation	Acquire appropriate clinical and laboratory data and correctly interpret the monitoring data to reach diagnosis	History, clinical examination Order appropriate examinations Interpret the results of the examinations ordered	[3–6]
Disease management	Acquire skills in integrating clinical and laboratory data to apply best practice guidelines. Regular clinical review to assess patient response.	Manage patients with acute disease and patients with exacerbations of chronic diseases. Manages the implications of comorbidities Manages acute system failure Manage intoxications Manage peripartum conditions	[3–6]
Therapeutic interventions/organ system support	Acquire skills in organ system support	Prescribe drugs/antimicrobial agents/blood products/fluids Initiate/manage/wean patients from mechanical devices Manage nutrition	[3–6]
Practical procedures	Facilitate organ support	RESPIRATORY SYSTEM Laryngoscopy, bronchoscopy, endotracheal intubation, tracheostomy, thoracentesis CARDIOVASCULAR SYSTEM Central and peripheral venous/arterial catheterization, cardiac defibrillation, cardioversion, cardiac pacing, pericardiocentesis, measure cardiac output CENTRAL NERVOUS SYSTEM Lumbar puncture, administration of analgesia via an epidural catheter GASTROINTESTINAL SYSTEM Nasogastric tube and Sengstaken tube placement, abdominal paracentesis RENAL SYSTEM Urinary catheterization	[3–6]
Perioperative care	Requires multidisciplinary collaboration	Manage pre and postoperative high risk patients	[3–6]
Comfort and recovery	Compassionate care for patients and families and initiation of rehabilitation	Identify physical and psychosocial consequences of critical illness Manage pain and delirium Communicate patients' needs Safely discharge the patient from the ICU	[3–6]
End-of-life care	Manage end-of-life issues	Manage the process of withholding and withdrawing treatment with the multidisciplinary team Discuss end-of-life issues with patients and families Manage palliative care Perform brainstem death testing Manage the physiological support of the organ donor	[3–6]
Pediatric care	Competencies that practitioners of adult ICM should have to manage a critically ill child until transfer to a pediatric center	Recognize an acutely ill child and provide initial care	[3–6]
Transport	Competencies for intra and inter-hospital transportation	Transport mechanically ventilated patients outside the ICU environment	[3–6]
Patient safety and systems management	Address system errors, create safer systems, and improve process and organization of care	Multidisciplinary ward rounds Comply with local infection protocols and apply guidelines, protocols, and care bundles Identify environmental hazards and minimize risks and critical incidences Organize case conference and understand managerial and administrative responsibilities	[3–6]
Professionalism	Acquire expertise and the privilege of self-regulation through vocation and service, personal development, and critical self-judgment under ethical standards Ability for clinical judgment	Communication skills (with patients, relatives, members of healthcare teams, keeps legible records) Professional relationship with patients and relatives (involve patient in decision-making, respect cultural and religious beliefs, privacy, dignity, and confidentiality) Professional relationship with members of the healthcare team (collaborate, consult, promote team working, ensures continuity of patient care-handling information, and supporting clinical staff outside the ICU) Self-governance (take responsibility for patient care, make clinical decisions under ethical and legal standards, seek continuation of learning, and participate in multidisciplinary teaching and research)	[3–6]

(*continued on next page*)

Table 2 (*continued*)

Domain	Description	Competence summary	References
CCUS-brain	Triage for intracranial hypertension		[19]
CCUS-thorax	Acquire skills for the examination of lung parenchyma, pleural space, and respiratory muscles		[19]
CCUS-heart	Acquire skills to evaluate the left and right ventricles, pericardium, and presence of severe valvulopathy		[19]
CCUS-abdomen	Acquire skills to evaluate traumatic and non-traumatic acute abdomen		
CCUS-vessels	Acquire skills to evaluate thrombosed vessels and perform ultrasonographic vessel catheterization		[19]
ECMO	Acquire skills to initiate, manage, and wean patients from ECMO	Cannulation Familiarize with the ECMO circuit Manage patients on ECMO Wean from ECMO	[3–6]
ASSESSMENT			
Supervision and In-training assessment	Informal assessment during routine clinical work Formal assessment and formal documentation of competence	Assessment of knowledge/skills/attitudes from local trainers	[11]
After-training assessment	National level	Oral examination Multiple Choice Questions Clinical examination Case-based discussion	[11]
After-training assessment	International level	EDIC diploma (ESICM) EDEC diploma (ESICM) ECMO diploma	

CBT: Competence-based training; CCUS: Critical care ultrasonography; ECMO: Extracorporeal membrane oxygenation; EDEC: European Diploma in Advanced Critical Care Echocardiography; EDIC: European Diploma in Intensive Care; ESICM: European Society of Intensive Care Medicine; ICM: Intensive care medicine; ICU: Intensive care unit.

ECMO, sepsis and trauma, antimicrobial stewardship, and research are currently available, either in-person or as e-learning courses. Moreover, the European Diploma in Echocardiography (EDEC) is a curriculum in echocardiography offered by the ESICM to practitioners who have acquired a basic level of competence in CCE and would like to extend their competencies to an advanced level (CME). Completion of EDEC training and competency-based testing designates that the intensivist is competent in advanced CCE.[57,64] The EDEC curriculum is currently in review, and new learning components consistent with the latest advances in CME will be proposed. On this basis, the ESICM organized training in general ultrasonography competencies in the ICU, thereby serving as a basis for the organization of intensivist training in CCUS (i.e., lectures, remotely supervised hands-on training, logbook, and final examination), in line with the EDEC process.

Mentorship programs

Mentoring has a positive impact on professional and academic careers, as well as decisions concerning specialty, scholarly productivity, and professional-personal life balance.[65–67] It involves coaching and educational roles, which require generosity of time, empathy, and willingness to share knowledge and skills. The mentor-mentee relationship creates a network of support and career opportunities for both parties concerned. Additionally, mentoring may positively affect team performance, as it may help in the retention of staff, professional development of individual members of a team, and planning for advanced professional roles.[68] Based on these benefits, mentorship programs are popular in critical care societies both in Europe and elsewhere.[69–71] Indeed, mentoring as a concept is largely supported in healthcare. However, mentoring programs can be challenging both in their creation and sustainability.[72] This is because it depends on and can be greatly affected by various factors, such as the mentor's own training, mentor-mentee compatibility, confidentiality, imbalance of power, and unrealistic expectations.[73–75] Therefore, mentorship programs should consider required qualities and abilities for effective mentorship. Objective, standardized metrics and outcomes should be specified and validated, and mentor training and faculty development programs that are directed at achieving defined outcomes should be developed.[67,74] Finally, academic bodies should plan and cater for all the aspects (e.g., workload, compensation, protected time, feedback, etc.) required for an efficacious mentorship program.

Implementation of large-scale training programs

Early during the COVID-19 pandemic, the ESICM leadership realized the need to develop a new training program aimed at preparing healthcare workers who do not normally work in critical care for deployment in ICUs during pandemic waves. Although this educational initiative was not designed to train future specialists in intensive care, it can serve as a basis for building efficient collaboration between healthcare workers and regular ICU teams.[76] The COVID-19 Skills PrepAration CoursE (C19_SPACE) covered aspects concerning: (1) personal safety (donning and doffing of personal protective equipment), (2) introduction to the ICU and ICU patients, (3) team care, (4) basics of respiratory support, (5) basics of hemodynamic monitoring, (6) sepsis and infections, and (7) other aspects of ICU care. Two sets of lectures were provided by the program — one for nurses and the other for doctors. The course consisted of an online component and on-site training, which were self-organized by local trainers.[76] The program was assessed using an evaluation questionnaire before and after the completion of training; and it was found to increase overall scientific knowledge.[76] Directed by the same vision, the American Thoracic Society (ATS) established an open-access COVID-19 Critical Care

Training Forum (CCCTF) with a plan to deliver weekly virtual sessions. The content related to all aspects of critically ill COVID-19 patient care, including inpatient and post-intensive care management.[77] Faced with surges in demand due to the pandemic and the ensuing pressure on ICU facilities around the world, both C19_SPACE and CCCTF training programs demonstrated that medical education can be successfully delivered globally and virtually in times of crisis.[76,77] The reliance on video conferencing during the pandemic created new opportunities for interface between academic institutions and the broader medical community. Furthermore, e-learning satisfies the need for continuing education and procedural training.

Data science – technology

The digitalization of the healthcare system is changing medical practice and clinical research and has prompted the rapid growth of data science in medicine.[78,79] Within the healthcare system, the ICU presents a particularly convincing case for using data science to improve patient care.[80] Big data analytics has immense potential for improving quality of care, helping physicians and nurses to make more personalized clinical decisions, reducing waste and errors, and possibly reducing the cost of care. Anticipating organ dysfunction before it occurs can be extremely helpful to adjust decisions and treatments.[80] Intensivists, however, are typically not trained to develop, implement, and evaluate such technologies. Training programs should be able to provide interdisciplinary team resources, which aim to interweave clinical training and a computer science background for big data analysis and machine learning. Teams with professionals across different fields are required. They should be composed of data scientists (including statisticians and epidemiologists), clinicians, and other biomedical researchers.[79] Effective leadership should be able to orient the coordination of a group with different schedules and be able to establish clear objectives to manage members of different cultures who may have different perspectives.

Simulation-virtual reality (VR)

Advancements in technology have changed the nature of medical education. Given the increased interest in safety, simulation has emerged as an essential element of clinical education. It includes training using task trainers, mannequins, human cadavers, animals, VR, and standardized patients, where the risk for making errors is negligible. Simulation has become an integral part of ICM training. Globally, 665 self-reported simulation centers exist for healthcare personnel working in an ICU environment. Moreover, 162 sites are accredited by the Society for Simulation in Healthcare, in the fields of assessment, research, integration, and teaching/education.[81] Simulation can be used to maximize in-person learning for those training in ICM, complementing traditional lectures and web-based learning resources. Simulation mastery learning programs include central venous catheter insertion, thoracentesis, management of mechanical ventilation, point-of-care ultrasonography. Additionally, they have been used in developing communication skills related to serious news disclosure, empathic support, eliciting patient values, cultural sensitivity, and shared decision-making.[81] Simulation-based training has been documented to be feasible and effective in improving education in the best practice management of mechanical ventilation and extra-corporeal membrane oxygenation.[82,83] Simulation-based training programs have been used to advance inter-professional team performance, which renders both improved teamwork and improved efficiency of care possible.[81] Furthermore, it can support and facilitate quality improvement of a healthcare system, having clinical team members practicing together and observing, thereby avoiding adverse events in day-to-day clinical management.[81]

Emerging technologies, such as VR, augmented reality (AR), and alternate reality have all altered the teaching field. In contrast to traditional mannequin-based simulation, VR can take place asynchronously, whenever convenient to the learner, and has provided highly-rated learning experiences due to increased realism and ability to provide data-rich analyses by tracking every user's input and interaction.[82] In ICM, VR has been used in bronchoscopy training, improving skill acquisition, time needed to complete a given procedure, and training efficiency; bronchoscopic-guided intubations have improved the time to intubation.[83,84] VR has been used in cardiopulmonary resuscitation, avatar-based gamification, and interprofessional training, including doctor-patient communication training, making each more effective and improving situational performance.

E-learning and networking

Trainees across Europe (ESICM) have organized webinars, workshops, and platforms to exchange knowledge and implement the continuation of educational programs. This has enabled the establishment and support of networking. Networking is defined as the process of interacting with peers, experts, and faculty members to exchange information and develop professional and social contacts.[85] Recent studies evaluated international networks using standardized frameworks for data quality.[86,87] Trainee networks may facilitate the spread of knowledge and enable communication among experts. Additionally, they can facilitate access to professionals from different centers and encourage activities that may initiate research collaborations. In this respect, these networks have the potential to improve multifactorial patient care. Despite offering a rich source of inquiry for large-scale longitudinal research, robust studies on trainee networks have definite shortfalls. The opportunity to encompass such benefits into the standard curricula has therefore been missed thus far.

Furthermore, the COVID-19 pandemic era has affected the learning procedure. Many current ICU training programs have been adapted by restructuring trainee schedules, teaching activities and rounding structures to balance clinical demands, educational efforts, and safety issues.[52,53] Physical distancing and the increased load on ICUs have highlighted the necessity of alternative learning strategies, which should be implemented, at least to complement formal ICM training procedures. The field of e-learning is growing quickly, and innovative technology has long served advances. However, the training process requires accreditation and quality assurance measures by a professional and statutory body for the specialty of ICM to ensure that e-learning produces "better" intensivists. Competency learning depends on the quality assurance framework and pedagogic context in which it is acquired.

Quality control

Irrespective of the training program followed by any given institution, a quality assurance program should be applied for quality improvement in training and patient care.[88] It should be a process conducted locally and managed by national training organizations. Regulatory authorities should explicitly set out the demands and responsibilities expected of trainers, program directors, and professional organizations to eliminate inconsistencies and assure the quality of such programs.[88,89] Quality control programs should evaluate factors that influence the acquisition of professional attitudes and behaviors, such as scholarship, reflective learning, and non-technical skills. CoBaTrICE developed a preliminary set of international standards for ICM training programs using consensus techniques.[56] This initiative was fully consistent with European initiatives that aimed to set procedures, standards, and guidance for higher education qualifications and was approved by the representatives of the national training organizations of all 28 European countries.[90,91] The final set of standards (summarized in four domains regarding training centers, programs, trainee selection, and trainer's profile) provided the framework for quality assessment of training programs and encouraged national training organizations, trainers, and trainees to ameliorate standards of training and clinical practice in ICUs.[56]

Implications

Until ICM is formally recognized as a specialty in the EU, European nations should collaborate under the Society of Intensivists to provide and guarantee adequate training in intensive care to ensure that every intensivist shares equal competencies, irrespective of the training institution. European standards for ICM training programs have been developed and approved by national training organizations of countries in Europe.[56] However, these arrangements can be considered as preliminary sets of a training framework in ICM, which will be completed when its scientific content, necessary technical tools, and resources are available at a national and regional level. This means that a substantial number of training posts, even in hospitals that do not have a strong academic infrastructure, should have access to training. The implementation of homogeneity at this level will help both in improving critical care science and providing standardized care.

Training needs to adapt to the fast pace of advances in current knowledge more than any period in the past. It needs to embrace novel technologies and bioinformatics (Table 3) and balance the shortcomings that are included in the agenda of critical care (i.e., leadership, interdisciplinary teamwork, gender, age, or other inequalities). Additionally, the training framework should embrace initiatives enhancing communication skills targeting key elements for compassionate, effective communication with family members of critically ill patients (e.g., leading meetings with family, discussing important decisions about goals of care, responding to family member distress, anger or grief, and so forth). Most importantly, plans toward establishing training have to face current limitations, such as the COVID-19 pandemic, emerging AMR to antibiotics, and/or other unforeseen future challenges. Undoubtedly, this necessitates an ongoing program of formal updates to curriculum content on the various aspects of critical illnesses. In this respect, international and national scientific societies and state organizations should continue to provide and promote opportunities for individual training.

Concurrently, a wide path should be kept open for trainees and professionals to help them broaden their knowledge and gain experience. This path should include interdisciplinary and inter-professional educational courses, workshops, practical training in bioinformatics, bioengineering, and initiatives for the supervision and mentorship of trainees. Moreover, regulations to redress gender and racial differences and guarantee equal gender representation in scientific training societies are needed to encourage trainees to achieve their full academic potential. Discrimination and inequities in patient care need analogous attention, possibly with initiatives by scientific societies to laud best practices and raise awareness among members. Understanding different cultures and belief systems in the context of free migration of individuals (and potentially future patients) and healthcare workers within the EU plays a key role. The consequence for a future European training curriculum could be to include rotations of trainees in other countries to better understand cultures and attitudes, in addition to raising the awareness of problems related to discrimination.

Table 3
Novel technologies for implementing ICM training.

Domain	Description	Competence summary	References
E-learning	Webinars, workshops, platforms	C19_SPACE training program (ESICM) ESICM ACADEMY CCCTF (ATS)	[8,24]
Simulation	Training using 1. Task trainers (body parts or structures) 2. Mannequins 3. Standardized patient (live person trained to portray a role or specific condition) 4. VR	1. Technical skills (central line insertion, intubation, bronchoscopy, mechanical ventilation management, thoracentesis, and ultrasound) 2. Assessment of competency 3. Interprofessional team training (blue code, decompensating patient on a ventilator, difficult airway, massive transfusion, and problem solving issues on ECMO) 4. Communication 5. Quality improvement	[27]
VR, AR, and alternate reality	Computer-generated three-dimensional interactive environment that gives an immersive effect to the trainer Asynchronous training program	Technical skills (bronchoscopy, cardiopulmonary resuscitation, bronchoscopic-guided intubation) Interprofessional training	

AR: Augmented reality; ATS: American Thoracic Society; C19_SPACE: Covid-19 Skills PrepAration CoursE[27]; CCCTF: COVID-19 Critical Care Training Forum; ECMO: Extracorporeal membrane oxygenation; ESICM: European Society of Intensive Care Medicine; ICM: Intensive care medicine; VR: Virtual reality.

Therefore, we should aim for a training framework that includes the central idea of assessing patients regardless of gender, age, race, or economic status, thereby cultivating a therapeutic alliance. The on-going COVID-19 crisis could give the ICM scientific community the opportunity to improve patient care and training by creating a forward-thinking generation of critical care trainees who are well equipped to face the formidable challenges of the future.

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Conflicts of Interest

Jordi Rello is Professor of Critical Care at Universitat Internacional de Catalunya and Chair of the Clinical Training Committee at the European Society Intensive Care Medicine. George Dimopoulos is Professor of Critical Care at National and Kapodistrian University of Athens, Executive committee member and Education officer of ESGCIP Critically Ill Patients Study Group of the European Society of Clinical Microbiology and Infectious Diseases (ESCMID). The manuscript reflects the opinion of the authors but does not represent the position of the Organizations. The other authors do not disclose potential conflict of interest.

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