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Effective training and support of ICU teams: The cornerstone for improved patient and staff outcomes

Susana M. Fernandes [a,b], Inês Pinto [b], Gonçalo Fernandes [a,b], Carla S. Correia [c], Paul Barach [d,e,*]

[a] Faculty of Medicine, University of Lisbon, Portugal
[b] Hospital Santa Maria, ULS Santa Maria, Lisbon, Portugal
[c] Business Research Unit (BRU-IUL), Instituto universitário de Lisboa (ISCTE-IUL), Lisbon, Portugal
[d] Thomas Jefferson University, Philadelphia, USA
[e] Sheps Center for Health Services Research, University of North Carolina, USA

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ABSTRACT

Background: ICU care is inherently multiprofessional, and communication failures and team dysfunction are implicated in a substantial proportion of preventable adverse events in critical care. However,et training frameworks remain fragmented, built around individual brilliance and siloed disciplines.
Aim: To present an integrated, evidence-based framework for building, training, assessing, and sustaining high-performance ICU teams.
Methods: Narrative review using a targeted, non-systematic search of the databases PubMed, Embase, Scopus, and Web of Science for manuscripts published between 2000 and June 2026. Grey literature from ESICM, SCCM, ANZICS was also searched. Data were synthesized by the authors from complex clinical scenarios and team behaviors, rather than by pooling empirical data. Themes, communication patterns, and organizational challenges emerged organically from the selected texts and case descriptions.
Key findings: ICU team effectiveness rests on four pillars: deliberate multiprofessional composition with explicit role delineation; multimodal training combining simulation, just-in-time training, and structured debriefing; rigorous measurement through structure, process, and outcome indicators; and organizational conditions, including unit design and psychological safety, that sustain safety culture and provider wellbeing. Current evidence remains heterogeneous, particularly across cultural, organizational, and resource contexts, limiting direct comparison across settings. Building on these pillars, practical recommendations for ICU leaders to translate this framework into daily practice are proposed.
Conclusion: A whole-team approach to ICU team selection, training and support, extending beyond physician-centric models, is clinically necessary and is operationally feasible when adapted to local resources and organizational conditions. The framework presented is adaptable to diverse and various intensive care settings, with each pillar mapped to actionable strategies for team composition, training, assessment, and sustainability.

1. Introduction

1.1. The modern ICU: complexity beyond the individual

Consider a composite scenario, illustrative of patterns recurring across ICU practice: a young adult polytrauma patient presented with severe intracranial hypertension, leading to prolonged prognostic uncertainty. For several days, there was a lack of shared treatment goals among the nursing staff, the intensive care team, the surgical team, and the patient's family. Following episodes of nosocomial septic shock, discussions regarding the potential withdrawal of life-sustaining therapies generated growing tension among team members. Ultimately, the patient made a full recovery, leaving the staff with an unspoken sense of a 'near miss.' No structured debriefing was conducted to address these team dynamics. This composite vignette illustrates recurring patterns observed across ICU practice and does not describe an identifiable patient or event.

Teamwork is the organizing framework that translates complex organ support and clinical diagnosis into patient-centered outcomes and aligned goals of care in the ICU. [1] The manner in which finite cognitive

* Corresponding author at: Thomas Jefferson University, Philadelphia, USA.
E-mail address: Paul.barach@jefferson.edu (P. Barach).

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resources are collectively distributed and coordinated under pressure influences performance in high-stakes environments [2]. For more than 30 years, a significant number of errors, many resulting in preventable harm, have occurred in the ICU, and many of these can be attributed to failed communication and non-technical skills. [3] The traditional model of the "heroic intensivist", centered on a single expert responsible for diagnostic and therapeutic decisions, is unsustainable in modern, multiprofessional, and complex intensive care, leading to a shift from individual work to team-based structures [4]. Teamwork is especially important when lives depend on collective knowledge and shared decision-making [5,6]. Of note, a group of people is only a team when they work together, address tasks interdependently, and are collectively responsible for them. [7,8] ICU teams operate in extreme environments, in which membership is fluid, decisions are made under uncertainty and clinical conditions evolve rapidly. Effective team performance requires shared decision-making, continuous information exchange, and coordinated bedside action. [9,10] Despite its relevance, teamwork is often taken for granted and not prioritized as one of the most important skills to train and reward for in intensive care units.

Prior reviews have cataloged ICU teamwork constructs and improvement strategies [11], focused on ICU team-training outcomes [12], or examined team situation awareness [13]; instead, this narrative review aims to integrate team composition, training, measurement, and organizational sustainability into a single, actionable framework for ICU leaders.(Table 1) Overall, the model integrates complementary elements from multiple approaches to teamwork and quality improvement into a single ICU-specific, lifecycle-oriented framework.

2. Methods

A narrative literature review was conducted to explore ICU team dynamics. A targeted search was performed across PubMed, Embase, Scopus, and Web of Science for English-language articles published between January 2000 and June 2026, supplemented by a manual snowballing search of foundational pre-2000 works (SMF, GF, CS, IP).

The search strategy was performed up to 30th of June of 2026 and encompassed three core domains: 1) teamwork and ICU dynamics (communication, interdisciplinary collaboration, cognitive workload, decision-making, and psychological safety); 2) clinical contexts; and 3) training modalities (simulation, crisis resource management (CRM), debriefing, and mastery learning). Grey literature searches included position statements from major critical care societies (ESICM, SCCM, ANZICS) and patient safety reports from the WHO and The Joint Commission. Literature focusing on undergraduate training or teamwork outside the ICU (e.g., emergency department or operating room) was excluded.

Given the conceptual and exploratory nature of this review, data were synthesized from complex clinical scenarios and team behaviors rather than pooling empirical data. Consequently, no formal quality appraisal of the manuscripts was performed. Data synthesis was conducted using an inductive, thematic approach. Themes, communication patterns, and organizational challenges emerged organically from the selected texts and case descriptions. These concepts were then integrated into a narrative structure, from which a set of actionable recommendations for ICU leaders emerged.

3. Narrative review results

The ICU is built to address a shared goal: improving the chances of survival and quality of life for sick patients, in an equitable and efficient manner. [14] The ICU staff requirements [15] and the competencies to achieve this goal are described in the guidelines. [16] Nevertheless, the basic staff structure varies across geographic areas (Table 2) [17–19], and studies have not clearly compared the impacts of different organizational and staff structures worldwide.

4. A shared mental model is formed by the key elements collecting and synthesizing patient data

4.1. The healthcare professionals, the Information Systems and the new AI teammate

At the core of the ICU team is the attending nurse and physician, usually a junior one in tertiary centers, supported by a senior consultant. These partners must work together in a trusting relationship. [21] The nursing workforce is the first responder, monitoring the patient, collecting data, involving family in patient care, and delivering treatments. [22] For nurse reports and handoffs to be part of a shared mental model [23], nurse involvement in decision-making and interprofessional respect are crucial. [24] Physicians -in-training play a pivotal role in gathering information from families, medical records, clinical observations, and tests to support diagnostic reasoning and therapeutic decision-making. [25,26] Additionally, physiotherapists, nutritionists, and other professionals join the core team during multidisciplinary ICU rounds (Table 2).

Digital transformation in the ICU, remote monitoring, and tele-ICU models have expanded the ICU team beyond physical boundaries, allowing off-site intensivists and critical care nurses to work alongside bedside clinicians. [27,28] Artificial intelligence (AI) is reshaping teamwork through the emerging paradigm of Human-Agent teaming (HAT). [29–31]. Rather than replacing clinicians, these agents are designed to collaborate with human team members by supporting information processing and decision-making.

Current AI-supported applications use predictive analytics within electronic health records (EHRs) to flag subtle signs of clinical deterioration, enabling teams to coordinate timely interventions. [32] AI analytics also require adaptation across systems. [33] Successful Human–AI teaming depends on calibrated trust, rather than on either over-reliance on AI, which reduces clinicians' willingness to critically evaluate algorithmic outputs, or under-utilization of AI recommendations due to

Table 1
Research Questions.

Domain	Objectives	Research Question	Terms used to search
Team Architecture	To define the core components and dynamics of an ICU team.	RQ1: What are the foundational elements that constitute an ICU team?	Intensive care units, ICU, critical care, team, teamwork, team professionals
Training & Development	To identify optimal educational and pedagogical strategies.	RQ2: How should ICU teams be trained and developed to ensure optimal performance in high-stakes environments?	Simulation, learning, team development, training, multiprofessional, critical care, ad-hoc teams, rounds
Measurement & Evaluation	To explore techniques for accurate effectiveness assessment.	RQ3: What metrics and methodologies can accurately measure and evaluate ICU team effectiveness?	Teamwork, team, outcome, shock, mechanical ventilation, ECMO-VV, ad-hoc teams, mortality, safety, burn-out
Sustainability & Viability	To analyze conditions for long-term organizational and psychological viability.	RQ4: Which organizational and psychological factors are essential to sustain ICU team performance and well-being over time?	Leadership, followership, critical care, emergency, psychological safety

ICU = Intensive Care Unit; RQ = Research Question.

Table 2
Global ICU Team Composition and Structure.

Region	ICU Model	Physician Leadership	Nursing Dynamics	Distinctive Team Elements
Europe [15,16]	Closed	Intensivist-led	~1:2 ratio (varies by North/South resources)	Physiotherapists manage early mobility and chest physiotherapy; no Respiratory Therapists (RTs).
United States [20]	Mixed (Open, Closed, Hybrid)	Intensivist-led (often supported by APPs due to shortages)	Variable (typically 1:2)	RTs are essential core members; heavy reliance on Advanced Practice Providers (NPs/PAs).
Australia & NZ	Strictly Closed	Intensivist (Consultant)-led	1:1 strictly mandated for complex/ventilated patients	Multidisciplinary roles (pharmacists, dietitians, physios) are heavily embedded and non-negotiable.
Asia [17]	Variable (Open prevalent; Closed in high-income areas)	Anaesthesiologists or Internists	Stretched ratios (often 1:3 or 1:4 in public hospitals)	Junior doctors absorb much of the clinical monitoring burden due to nursing shortages.
Africa [18,19]	Predominantly Open	Anaesthesiologists or Surgeons (splitting time with OR)	Severe shortage of specialized critical care nurses	Allied health care personnel not routinely part of the team

APPs = Advanced Practice Providers; ICU = Intensive Care Unit; NPs = Nurse Practitioners; NZ = New Zealand; OR = Operating Room; PAs = Physician Assistants; RTs = Respiratory Therapists.

mistrust. [31] Consequently, AI recommendations should remain transparent, be interpreted within multidisciplinary discussions, and be continuously evaluated alongside the bedside assessment, clinical reasoning, and effective team communication. Accountability for AI supported clinical decisions remain with the treating clinician and team whether an AI recommendation is followed or overridden, under European (EU AI Act Article 6/Annex I) and American (FDA Clinical Decision Support Software Guidance) laws, rather than with the algorithm or its developer. This boundary of responsibility should itself be a driver for critical-thinking training across every member of the team, not only its formal leaders.

During multidisciplinary ICU rounds, patient problems are reviewed, and difficult decisions are made. These decisions rely on completing a daily goals checklist, based on information summarized by team members [34], which may introduce bias into decision-making. Involvement of junior and senior trainee doctors in decision-making is associated with better patient care outcomes. [35]

Structured communication using frameworks such as SBAR (Situation, Background, Assessment, Recommendation) has been associated with improvements in patient outcomes and may contribute to reductions in preventable adverse events, although the strength and consistency of evidence vary across settings. SBAR functions as a cognitive scaffold to improve team coordination, reduce information omissions, and support clinical decision-making. [36] Another relevant tool for rounds is the STICC protocol (Situation assessment, Task comprehension, Intent, Concern, Calibrate), which can help forecast the unexpected. [37] Patients may die overnight despite no concerns being raised the previous day. This can be quantified by assessing the team's situational awareness.

4.2. The patient and family as members of the team

Patients [38] and families are active members of the clinical microsystem team, contributing to shared decision-making [39] and patient outcomes. [40] The family provides experiential expertise complementing the clinician's technical expertise and offering insights into the patient's baseline function, preferences, communication style, and therapeutic goals. [41] Integrating this information, palliative care, psychology, and ethics [42] into clinical decision-making can enrich the patient's understanding, promotes shared situational awareness, and supports a personalized care process. [39] Additionally, the family can help bridge care transitions by maintaining continuity across healthcare professionals and preserving information that might otherwise be lost during patient handovers. [38] Following the ABCDEF bundle, family engagement is crucial to high-quality intensive care. [43,44]

5. Human factors engineering: the basis of ICU team performance

Teamwork does not occur in a vacuum. It is enacted within and constrained by the ICU's physical [45], cognitive, and technological environment. Human factors engineering designs systems, workspaces, and tools around the capabilities and limits of the people who use them, rather than expecting people to adapt to poorly designed systems. A team with excellent communication skills operating in a poorly designed, interruption-heavy environment will still make errors that can lead to harm. [46]

This cognitive overload comes from bedside physiological data, EHR dashboards, clinical decision-support interfaces and non-actionable alarms. [47] It is a systems problem involving acoustics, workflow design and cognition [48]. Digital usability is therefore a patient safety property of the technology itself. Well-designed interfaces co-designed with AI tools can protect the team's limited attention, contributing to enhanced situational awareness, and reduce unnecessary cognitive burden. Resilience engineering facilitates adaptive behaviors through manageable workloads, recoverable interfaces, and redundancy *that absorbs* disruption rather than transmits it downstream.

In addition, the ICU design shapes team functioning [45], and the architecture interacts with technology, human factors and communication to impact patient outcomes. [46] Evidence-based design supports multidisciplinary teamwork by optimizing visibility, ergonomics, and noise reduction, thereby reducing errors and improving situational awareness. [49]

6. Team coordination and enhanced cognition

ICU team cognition must be cultivated to encompass cross-monitoring and collective clinical sensemaking [50] and to develop the capacity to make sense of complex clinical situations. Accordingly, contemporary theories of ICU teamwork conceptualize critical care teams as complex adaptive systems requiring distributed cognition, dynamic coordination, and continual adaptation. This shared cognitive architecture fosters trust and adaptive resilience, enabling the interprofessional team to rapidly reallocate cognitive resources, bypass decision-making bottlenecks, and maintain situational awareness when standard clinical pathways are disrupted. [51]

The “Big Five of Teamwork” model is still the most influential model for deciphering team coordination and team effectiveness (Table 3). [52] ICU strategic leadership – through close collaboration between medical and nursing leaders – defines unit goals, coordinates relationships with other services, and help to organize work through task delegation and feedback. [53,54] Transactional, transformational, and active leadership are associated with team resilience and performance. [55]

Intensive care experts also provide operational leadership in daily practice and during emergencies, where crew resource management (CRM)-trained leaders have shown to improve team performance and task allocation. [56] Effective leadership depends on active followership, including engagement, critical thinking, speaking up and supporting the team leader's role, communication, adaptability, and

Table 3
The Big Five dimensions of ICU teamwork [52,66] with ICU-specific exemplars.

Dimension	Definition	ICU Manifestation	Consequence of failure	Trainability
Team Leadership	Coordinating member activities, assigning tasks, and facilitating a positive, productive team climate	Intensivist directing patient ICU admission; dynamic role handover at shift change	Role duplication, task gaps, no speak-up during rounds, emergency settings or other critical moments.	CRM, simulation
Mutual Performance Monitoring	Tracking teammate performance to identify errors and ensure procedures are followed accurately	Nurse flags rising lactate; pharmacist catches dosing error	Siloed charting prevents cross-professional awareness	Structured rounds, shared dashboards
Backup Behavior	Anticipating needs and shifting workloads to assist overtaxed or struggling team members	RT assists nurse with prone positioning; senior covers junior during procedure	Help not offered unless explicitly requested; hierarchy paralysis	TeamSTEPPS, debriefing
Adaptability	Adjusting team strategies and reallocating resources in response to environmental changes or deviations	Switch from standard mechanical ventilation weaning to ECMO support on acute unexpected deterioration	Rigid protocol adherence when deviation is indicated	Simulation, JITT
Team Orientation	Prioritizing collective goals over individual ones and considering teammates' perspectives during group interactions	Shared ownership of IAP bundle; joint M&M case review	Blame culture undermines collective accountability	culture interventions, leadership training

CRM = Crisis Resource Management; ECMO = Extracorporeal Membrane Oxygenation; ICU = Intensive Care Unit; JITT = Just-in-Time Training; M&M = Morbidity and Mortality; RT = Respiratory Therapist; TeamSTEPPS = Team Strategies and Tools to Enhance Performance and Patient Safety; IAP = Intubation-Associated Pneumonia

commitment to shared goals. [57,58] Together, leadership and followership shape the remaining dimensions of teamwork and influence hierarchy, patient safety, burnout, and team resilience. [59,66] High levels of psychological safety and perceptions of leaders' inclusiveness are required to speak up, ask questions, or admit mistakes. [60] A collective perception among colleagues that interpersonal risks can be taken without fear of personal consequences enables clinicians to speak up when new information challenges assumptions or expectations. [61,62] In fact, when concerns about embarrassment or appearing incompetent are reduced, team members are more likely to seek assistance and disclose medical errors. [63,64] Fear, intimidation, and psychologically unsafe work environments frequently silence nurses and residents, weakening the organization's ability to detect and recover from patient safety threats. [65]

7. Training teamwork: the development of a continuous learning system

The big five dimensions, underpinned by shared mental models, mutual trust, and closed-loop communication, can each be mapped onto training interventions such as simulation, team training programs, and structured communication protocols. (see Table 4)

Improving teamwork should be centered on role clarity, psychological safety, teaming, and empathy [67]. Barriers like turnover, time constraints, evolving care plans, training feasibility [68], and individual development should be considered. [69]

Competencies and procedures can be trained via simulation [70] and just-in-time training (JITT), moving beyond “see one, do one, teach one” [71] toward mastery learning. Interprofessional performance, confidence, and communication should be rehearsed in scripts for cardiac arrest, trauma, and difficult airway management [72,73] Digital twins may also support scenario development by simulating ICU complexities [74].

JITT allows teams to rehearse skills and behaviors before clinical events [75,76]. It can benefit from mental rehearsal before procedures, and can occur after daily-plan reviews, before high-risk/low-frequency procedures, and/or during new equipment rollout. [77]

Deficits in delegation and recognition of deterioration, identified using simulation, [84] suggest these skills require case-specific repetition, not one-off training. Interprofessional teaching [78], serious gaming [79,80], and forums like M&M meetings—dependent on psychological safety—offer venues for deep reflection and learning.

8. Measure teamwork: the Donabedian Learning Model for ICU Management

Measurement indicators are essential to evaluate teamwork interventions. Donabedian's learning system model, when applied to ICU management, supports the view that high-quality outcomes emerges from the interactions between well-designed structures (governance,

Table 4
ICU team training modalities: scenario types, core competencies, evidence level, and key limitations.

Training Modality	Primary Scenario	Core Competency	Evidence Level	Key Limitations
Simulation (high-fidelity)	HALF events; cardiac arrest; difficult airway	CRM; closed-loop communication; shared mental model	High (RCTs, systematic reviews)	Cost; faculty burden; transfer-to-outcome gap
In situ simulation	Systems failures; multi-patient deterioration	Latent threat identification; team systems	Moderate (cohort studies)	Disrupts clinical workflow if poorly timed
Just-in-Time Training	ECMO cannulation; tracheostomy; new protocols	Cognitive offloading; skill decay; pre-task alignment	Moderate (before–after studies)	Facilitator-dependent; hard to standardize across shifts
Hot Debriefing	Any acute event; resuscitation; rapid deterioration	Shared factual account; immediate safety review	Moderate (observational)	Requires trained facilitator; fatigue impairs quality
Cold Debriefing / M&M	Sentinel events; near-misses; complex cases	Systemic analysis; latent threat identification; CQI	Moderate (qualitative, cohort)	Scheduling barriers; psychological safety prerequisite
Non-clinical forums	Case reviews; protocol design; academic discussion; serious games	Professional identity; shared mental model; culture	Low-moderate (expert consensus)	Hard to mandate; variable engagement

CQI = Continuous Quality Improvement; CRM = Crisis Resource Management; ECMO = Extracorporeal Membrane Oxygenation; HALF = High-Acuity, Low-Frequency (events); ICU = Intensive Care Unit; M&M = Morbidity and Mortality; RCTs = Randomized Controlled Trials.
Evidence levels were assigned according to the design and methodological strength of the available literature: High- reflected evidence supported by randomized controlled trials and/or systematic reviews; Moderate- reflected primarily observational, cohort, before–after, or qualitative evidence; and Low– reflected predominantly expert consensus or limited empirical evidence. These categories were used descriptively and do not represent a formal risk-of-bias or GRADE assessment.

Table 5
Structure–Process–Outcome indicators for ICU team assessment.

Indicator	Validated Tool / Benchmark	Who It Measured By
Structure		
Bed-side Team composition Average Nurse:patient ratio in 24 h Intensivist:patient ratio in 24 h	NEMS; TISS-28	Nurse manager; medical director
Physical environment for communication	Built environment checklist (AHRQ)	Facilities / quality team
Electronic medical records	Integrating EMR tools	CMIO/Nurse lead
Process		
Multidisciplinary rounds [82]	Leadership involvement Number of disciplines involved in clinical rounds	Quality/safety officer
Daily goals completion	Daily Goals Sheet (Pronovost)	Charge nurse daily audit
Handoff quality	ISBAR compliance audit	Quality/safety officer
Safety culture	SAQ; TeamSTEPPS TPQ	Annual unit survey
Outcomes		
IAP, CLABSI rates	CDC NHSN benchmarks	Infection control
Errors and near miss reports		Unit Quality/ Safety head
Staff burnout / moral distress	MBI; MDS-R	HR / wellbeing programme
Psychological safety	Edmondson 7-item scale	Team leader; annual survey

AHRQ = Agency for Healthcare Research and Quality; CDC = Centers for Disease Control and Prevention; CLABSI = Central Line-Associated Bloodstream Infection; CMIO = Chief Medical Information Officer; EMR = Electronic Medical Record; IAP = Intubation-Associated Pneumonia; ICU = Intensive Care Unit; ISBAR = Identify, Situation, Background, Assessment, Recommendation; MBI = Maslach Burnout Inventory; MDS-R = Moral Distress Scale–Revised; NEMS = Nine Equivalents of Nursing Manpower use Score; NHSN = National Healthcare Safety Network; PREMs = Patient-Reported Experience Measures; PROMs = Patient-Reported Outcome Measures; SAQ = Safety Attitudes Questionnaire; TISS-28 = Therapeutic Intervention Scoring System, 28 items; TPQ = Teamwork Perceptions Questionnaire.

staffing, technology, and resources) and reliable care processes (communication, teamwork, protocols, and continuous learning). **Structure indicators** create the conditions for safe work (staff ratios, strategies for coping with staff shortages, such as job-description reassignment, ICU design and digital systems); **process indicators** represent the adaptive behaviors of clinicians within those conditions (communication, measured through compliance with standardized handover protocols (e.g., ISBAR), effectiveness of interdisciplinary rounds, and the use of closed-loop communication during emergencies [81] or adherence to clinical pathways, such as sepsis bundles); **outcome indicators** provide feedback that drives the redesign of both structures and processes (Table 5).

Outcome indicators represent the tangible results of the team's actions and are categorized as patient-centric (mortality rates, incidence of preventable adverse events [82], rehabilitation processes [83], humanized care [84]) and team-centric (staff burnout, professional turnover, and perceived team cohesion [61]). Finally, patient outcome indicators should include Patient-Reported Outcome Measures (PROMs) [85], such as physical, mental, and social health after critical illness, and Patient-Reported Experience Measures (PREMs), which assess the quality of communication, shared decision-making, and alignment of care with patient and family values. Routine measurement should nevertheless be proportionate to local resources. Not all indicators need to be collected continuously: high-burden measures, such as detailed teamwork assessments or staff surveys, may be collected periodically, whereas lower-burden process indicators, such as handoff compliance or daily-goal completion, should be incorporated into existing daily quality-improvement workflows. Responsibility should be assigned to existing roles, such as nurse managers, quality and safety teams, or medical leadership, rather than creating parallel coordination systems.

9. Implementing teamwork as a benchmark of the ICU

Building a patient-centered ICU system supported by effective teams requires a clear implementation strategy and a culture of continuous learning. Reflective debriefing and Rapid Cycle Deliberate Practice promote team improvement through rapid learning [86].

Hot debriefing can play an important role in staff wellbeing and self-care, helping prevent self-blame and the normalization of stressful situations. [87] Despite their relevance, the use of structural or informal debriefing strategies in ICUs remains uncommon and highly culture-dependent. [88] Ignoring these cultural differences when interpreting data or implementing teamwork strategies can lead units and institutions to fail.

The Consolidated Framework for Implementation Research (CFIR) provides a useful structure for planning and assessing ICU implementation strategies (Table 6). This framework sets the plan for an implementation strategy that must include several cycles of plan-do-study-act (PDSA) tailored to the ICU context. [89] Success of the implementation strategy will ultimately depend on protected time, ongoing learning, outcome monitoring and continuous feedback.

Despite more than 30 years of research, the ICU teamwork literature remains confusing and highly heterogeneous, with limited representation of the varied contexts characterized by different cultural norms [90], power distances, or varying trust levels. No formal quality appraisal was performed as with most narrative reviews that combine heterogeneous sources, limiting the ability to weigh conflicting or lower-quality evidence.

In the next years, research funders seeking to improve the ICU

Table 6
The CFIR Application to Teamwork Innovations and Examples in the Intensive Care Unit.

Domain	Innovation (Intervention)	Inner Setting	Individuals	Process	Outer Setting
Communication	In situ simulation program	Unit safety culture & Psychological safety	ICU Leadership & Multidisciplinary team	Routine hot debriefing after stressful clinical events	National ICU & Resuscitation Standards
New Equipment	Multimodal mechanical ventilation monitoring	Equipment compatibility (existing ICU ventilators)	Respiratory Therapists & Intensivists	Identification of clinical champions & Just-In-Time Training (JITT)	International respiratory and critical care guidelines
Procedural Safety	Standardized central line insertion checklist	Infection prevention policies & Safety culture	Physicians & Bedside Nurses	Audit and feedback on checklist compliance	National and international CLABSI prevention guidelines
Clinical Bundles	Family presence during multidisciplinary rounds (ABCDEF bundle)	Unit visitation policies and Workflow adaptability	ICU clinical team and Family representatives	Staff training on family engagement & Structured communication protocols	National patient-centered care guidelines and Outpatient networks

ABCDEF = Assess/prevent/manage pain, Both spontaneous awakening and breathing trials, Choice of analgesia/sedation, Delirium assessment/prevention/management, Early mobility, Family engagement (ICU Liberation Bundle); CFIR = Consolidated Framework for Implementation Research; CLABSI = Central Line-Associated Bloodstream Infection; ICU = Intensive Care Unit; JITT = Just-in-Time Training.

Table 7
Recommendations to support ICU teams performance and improved outcomes

Domain	Research Question	Recommendations
Team Architecture	RQ1: What are the foundational elements that constitute an ICU team?	1) implement a team with multidisciplinary skills 2) develop leadership and followership as trainable core competencies; 3) include patients and families as active team members, not merely as recipients of information;
Training & Development	RQ2: How should ICU teams be trained and developed to ensure optimal performance in high-stakes environments?	1) train the whole multidisciplinary team together, across roles, rather than in uni-professional silos; 2) debrief routinely, after everyday cases and not only after major critical events.
Measurement & Evaluation	RQ3: What metrics and methodologies can accurately measure and evaluate ICU team effectiveness?	1) measure teamwork and psychological safety, using validated instruments; 2) monitor burnout systematically, as a marker of team and system health, not of individual failure.
Sustainability & Viability	RQ4: Which organizational and psychological factors are essential to sustain ICU team performance and well-being over time?	1) apply implementation science methods so that teamwork interventions are adopted, sustained, and adapted to the local context; 2) develop psychological safety as a deliberate practice; 3) build learning systems that capture data from daily practice, debriefings, and outcomes to drive continuous cycles of improvement without extra burden of work

function and patient outcomes d should consider supporting consensus on outcome reporting across ICU teamwork interventions; develop longitudinal cohort studies measuring sustained team performance over time; and, evaluate the effectiveness of virtual reality and AI-augmented simulation in low-resource ICU settings. In addition, team-level psychological safety should be treated as a routine quality indicator. The impact of family members' active integration into the team should be evaluated (See Table 7).

10. Conclusions

The ICU of the future will not be defined solely by technological sophistication, but by the capacity of teams to learn more effectively by coordinating cognition, communicating uncertainty, adapting under pressure, and sustaining trust across increasingly complex systems. Returning to the opening vignette, each unresolved gap maps onto one of this review's four pillars. The absence of shared treatment goals across team members reflects a gap in team architecture (RQ1) as role and goal alignment were never explicitly structured. The tension that accumulated during withdrawal-of-care discussions reflects a training gap (RQ2): no team member was equipped to navigate high-stakes disagreement under prognostic uncertainty. The absence of a structured evaluation of this near miss reflects a measurement gap (RQ3), as without routine assessment, the event remains invisible to quality systems. And the unspoken, non-debriefed near miss reflects a sustainability gap (RQ4): without psychological safety and a learning system to process it, the team's tacit knowledge was lost rather than converted into sustained organizational learning.

We propose a novel ***conceptual framework*** in which effective ICU teams are deliberately composed, are multidisciplinary, systematically trained, rigorously assessed, and intentionally sustained. Critically, each pillar is actionable: team composition can be mapped against the nested roles framework; training can be structured around the four-modality ecosystem; assessment should use validated Donabedian Structure–Process–Outcome indicators; and, the team sustainability requires deliberate cultural and institutional investments. Patient outcomes will differ from one ICU setting to the next, shaped by cultural, leadership, political, and economic realities. What remains constant is the evidence: teams that work better together trust each more and more consistently deliver better outcomes for their patients and communities.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the authors used Claude for Mac (Version 1.22209.0 (77c938)) to rewrite ideas in English and organize information. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

CRediT authorship contribution statement

Susana M. Fernandes: Writing – review & editing, Writing – original draft, Visualization, Supervision, Investigation, Formal analysis, Conceptualization. **Inês Pinto:** Writing – original draft, Visualization, Resources, Investigation. **Gonçalo Fernandes:** Writing – original draft, Methodology, Investigation, Formal analysis. **Carla S. Correia:** Writing – original draft, Visualization, Validation, Methodology, Funding acquisition, Formal analysis. **Paul Barach:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

Ethics approval and consent to participate

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Declaration of competing interest

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Consent for publication

Not applicable.

Central argument

Effective ICU teams are not spontaneously assembled — they are deliberately composed, systematically trained, systematically assessed, and intentionally sustained to generate shared situational awareness. Existing ICU teamwork reviews typically focus on one domain—communication, simulation, CRM, leadership, or handoffs—whereas this review proposes an integrated implementation framework spanning team design, training, measurement, organizational support, and continuous learning.

Gaps addressed

Most ICU teamwork literature addresses isolated interventions (e.g., simulation or teamwork reviews handoffs alone). This review provides an integrated, lifecycle framework, from team composition through sustained leadership and culture, grounded in the Salas Big Five model, Donabedian's Learning System, human factors, and implementation science.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Susana Mendes Fernandes reports a relationship with AOP Health that includes fees for travelling and conference attending. The other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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