Journal of Advances and Scholarly Research In Allied Education
Vol.23, Issue No.4 July 2026, ISSN 2230-7540

Impact of Multidisciplinary Teamwork on Patient Outcomes in Respiratory Emergencies: A Narrative Review

Ahad Mohammed AlZahrani[1*], Norah Fahad Aldawsari[2], Sarah Sharif Alghamdi[3], Faisal Khalid Aloud[4], Safiah Saud Almarri[5], Hajar Fahad Alsunbul[6], Fahad Talal Bin Tayyash[7], Nujoud Hamad alqahtani[8], Raghad Suliman Alomer[9], Saud Khalid Alotaibi[10]

[1] Respiratory Therapy Specialist, Prince Sultan Military Medical City, Riyadh KSA

[2] Respiratory Therapy Specialist, Prince Sultan Military Medical City, Riyadh KSA

[3] Nursing Specialist, Prince Sultan Military Medical City, Riyadh KSA

[4] Biomedical equipment technology, Prince Sultan Military Medical City, Riyadh KSA

[5] Special nurse, Prince Sultan Military Medical City, Riyadh KSA

[6] Special nurse, Prince Sultan Military Medical City, Riyadh KSA

[7] Nursing Specialist, Prince Sultan Military Medical City, Riyadh KSA

[8] Nursing Specialist, Prince Sultan Military Medical City, Riyadh KSA

[9] Nursing Specialist, Prince Sultan Military Medical City, Riyadh KSA

[10] Emergency Medical Technician, Prince Sultan Military Medical City, Riyadh KSA

Trusfhe@hotmail.com

Abstract: Background**.** Respiratory emergencies — acute exacerbations of chronic obstructive pulmonary disease (COPD), status asthmaticus, severe community-acquired pneumonia, acute respiratory distress syndrome (ARDS), high-risk pulmonary embolism and acute hypoxaemic or hypercapnic respiratory failure — are among the most time-critical presentations in acute care. Their management is inherently distributed across physicians, nurses, respiratory therapists, pharmacists, physiotherapists and allied staff. Whether the *quality of the collaboration* between these disciplines independently influences patient outcomes, over and above the individual interventions delivered, has become a central question in critical care quality improvement.

Objective**.** To synthesise the conceptual, empirical and implementation literature on multidisciplinary and interprofessional teamwork in respiratory emergencies, to identify the mechanisms through which teamwork is translated into measurable patient benefit, and to define the methodological limits of the current evidence base.

Methods**.** A narrative review informed by a structured search of MEDLINE/PubMed, CINAHL, Embase, the Cochrane Library and Scopus for literature published between January 1995 and December 2024, combining team-related and respiratory-emergency-related terms. Landmark trials, systematic reviews, meta-analyses, professional society guidelines and observational cohorts were prioritised; reference lists were hand-searched.

Findings**.** Convergent evidence from several distinct team models — rapid response and medical emergency teams, protocolised ventilator liberation led by nurses and respiratory therapists, structured difficult-airway teams, pulmonary embolism response teams (PERT), extracorporeal membrane oxygenation (ECMO) programmes and interprofessional ICU rounding — associates organised multidisciplinary working with reduced mortality, shorter duration of mechanical ventilation, shorter intensive care and hospital length of stay, higher first-pass intubation success, fewer peri-intubation complications, better guideline and bundle adherence, and improved family experience. Effect sizes are heterogeneous and are strongly conditioned by implementation fidelity, baseline organisational performance and case mix. The causal pathway appears to run through shared mental models, closed-loop communication, explicit role allocation, psychological safety, distributed cognitive load and structured information transfer rather than through team composition alone.

Conclusions**.** Multidisciplinary teamwork is best understood not as an adjunct to clinical care in respiratory emergencies but as a determinant of whether evidence-based interventions are delivered reliably, completely and in time. The principal research gaps are the scarcity of adequately powered cluster-randomised designs, the absence of a standardised core outcome set linking team process measures to patient endpoints, and the near-total under-representation of low- and middle-income settings.

Keywords: multidisciplinary teamwork; interprofessional collaboration; respiratory failure; critical care; patient outcomes; rapid response teams; mechanical ventilation; crisis resource management; patient safety

1. INTRODUCTION

Few clinical situations expose the collective, rather than individual, nature of medical work as starkly as a respiratory emergency. A patient deteriorating towards intubation is simultaneously the object of assessment, monitoring, drug preparation, airway equipment assembly, ventilator configuration, documentation and family communication. No single clinician performs all of these. The outcome therefore depends not only on whether each professional possesses the relevant technical competence, but on whether their actions are sequenced, coordinated, communicated and mutually monitored under time pressure.

This observation is not new. The Institute of Medicine's *To Err Is Human* placed communication and coordination failures at the centre of preventable harm in hospitals, and subsequent sentinel event analyses have repeatedly identified breakdowns in team communication as a leading contributory factor in serious safety incidents [1,2]. What has changed over the past two decades is the accumulation of empirical work attempting to quantify the relationship — to move from the plausible assertion that "good teams do better" to defensible estimates of effect on mortality, ventilator days and length of stay.

Respiratory emergencies constitute a particularly informative domain for this question, for four reasons.

First, **they are common and lethal**. Acute respiratory failure is the single most frequent reason for intensive care admission worldwide, and acute exacerbations of COPD alone account for a substantial proportion of unplanned medical admissions in most health systems [3,4]. ARDS remains associated with hospital mortality of roughly 35–45% across large multinational cohorts, and severe pneumonia continues to carry high case fatality despite advances in antimicrobial therapy and organ support [5,6].

Second, **the therapeutic window is narrow**. In refractory hypoxaemia, in tension physiology, in severe bronchospasm and in high-risk pulmonary embolism, the interval between recognition and definitive action is measured in minutes. Coordination failures that would be recoverable in elective care become consequential.

Third, **the evidence base for the individual interventions is mature**. Lung-protective ventilation, prone positioning, non-invasive ventilation for hypercapnic exacerbations of COPD, early spontaneous breathing trials, systemic corticosteroids in asthma and COPD, and reperfusion in massive pulmonary embolism are all supported by high-quality trial evidence [7–13]. When the *what* is settled, residual variation in outcome is attributable disproportionately to the *how* — that is, to delivery and organisation.

Fourth, **the workforce is irreducibly multidisciplinary**. Respiratory therapists (or physiotherapists in systems without a distinct respiratory therapy profession) hold operational expertise in ventilator management that physicians frequently do not; critical care nurses hold continuous surveillance data that no intermittent assessment can replicate; pharmacists hold dosing and interaction knowledge critical in rapid sequence induction and in nebulised and infused bronchodilator therapy. The knowledge required to manage a respiratory emergency well is distributed by design.

This review examines what is known about the relationship between the organisation of that distributed expertise and the outcomes patients experience. Section 2 describes the review method. Section 3 sets out the conceptual and theoretical foundations, including the frequently conflated distinctions between multidisciplinary, interdisciplinary and transdisciplinary working. Section 4 characterises the clinical landscape. Sections 5 and 6 present the evidence from specific team models and the outcome domains they affect. Section 7 addresses mechanism — the intermediate processes through which teamwork acts. Sections 8 to 10 consider barriers, measurement and implementation. Section 11 identifies research gaps.

2. METHODS

This is a narrative review with a structured and reproducible search strategy, rather than a systematic review with formal risk-of-bias assessment and quantitative pooling. The narrative form was chosen deliberately: the literature spans clinical trials, organisational psychology, human factors engineering, health services research and implementation science, and the heterogeneity of designs, comparators and outcome definitions precludes meaningful meta-analysis across the field as a whole.

Search strategy. MEDLINE/PubMed, Embase, CINAHL, the Cochrane Library and Scopus were searched for records published between January 1995 and December 2024. Search strings combined three concept blocks using Boolean operators:

- ***Team concepts:*** "multidisciplinary team", "interdisciplinary team", "interprofessional collaboration", "teamwork", "crew resource management", "crisis resource management", "team training", "TeamSTEPPS", "non-technical skills", "closed-loop communication", "shared mental model".
- ***Clinical concepts:*** "respiratory failure", "acute respiratory distress syndrome", "COPD exacerbation", "status asthmaticus", "mechanical ventilation", "airway management", "rapid sequence intubation", "pulmonary embolism", "extracorporeal membrane oxygenation", "respiratory emergency", "rapid response team", "medical emergency team".

- ***Outcome concepts:*** "mortality", "length of stay", "ventilator-free days", "complications", "patient safety", "adverse events", "readmission", "guideline adherence".

Inclusion criteria. English-language studies of adult or mixed adult–paediatric populations reporting patient-level outcomes, team process outcomes, or both; systematic reviews and meta-analyses; professional society guidelines and consensus statements; validated team measurement instrument development papers; and theoretical or conceptual papers of sufficient standing to inform the framework used here.

Exclusion criteria. Single case reports without process analysis; conference abstracts without full-text publication; studies of teamwork in exclusively elective or non-acute settings without transferable mechanistic content.

Synthesis. Included sources were grouped thematically into (i) conceptual and theoretical foundations, (ii) team models and their outcome evidence, (iii) mechanisms and mediators, (iv) measurement, and (v) implementation and barriers. Where multiple systematic reviews addressed the same question, the most recent and most methodologically rigorous was prioritised, with earlier reviews retained where they contributed distinct data.

Limitations of the method. No formal quality appraisal instrument was applied, no protocol was registered, and no grey literature search was conducted. Selection bias in favour of well-cited and positive studies cannot be excluded. The findings should be read as an interpretive synthesis rather than as a quantitative estimate of effect.

3. CONCEPTUAL AND THEORETICAL FOUNDATIONS

3.1 Terminological precision: multidisciplinary, interdisciplinary, transdisciplinary

The terms are routinely used interchangeably in the clinical literature, which obscures a meaningful gradient of integration.

A **multidisciplinary** team comprises members of several professions who each contribute according to their own disciplinary framework, coordinating their outputs but retaining separate assessments, separate goals and separate documentation. The classical ward round in which each discipline reports sequentially is multidisciplinary.

An **interdisciplinary** team integrates at the level of assessment and planning: members negotiate a shared formulation of the problem and a common set of goals, and their contributions are interdependent rather than merely additive. The structured ICU round with a shared daily goals instrument is interdisciplinary.

A **transdisciplinary** team goes further, with deliberate role blurring and cross-training such that members can execute selected tasks conventionally belonging to another discipline. Protocolised weaning executed by a respiratory therapist without physician order for each step, or nurse-initiated non-invasive ventilation under standing protocol, are transdisciplinary in this sense.

Most empirical studies described as evaluating "multidisciplinary teamwork" in respiratory emergencies are in fact evaluating interdisciplinary or transdisciplinary arrangements. This matters for interpretation: the observed benefits typically arise from *integration*, not from mere *co-presence*. Studies that increase the number of professions present without altering the interaction structure would not be expected to produce, and generally have not produced, comparable effects.

For readability, this review uses "multidisciplinary" and "interprofessional" as the umbrella terms, and specifies the degree of integration where the distinction is material to the finding.

3.2 Team effectiveness frameworks

Several theoretical models structure the empirical literature.

The input–mediator–output–input (IMOI) framework treats team composition, task characteristics and organisational context as inputs; teamwork processes and emergent states as mediators; and performance and patient outcomes as outputs, with feedback loops in which outputs become subsequent inputs. Nearly all serious health services research on teams is implicitly organised on this logic, and it is the framework adopted here.

The "Big Five" of teamwork identified by Salas and colleagues specifies five core behavioural components — team leadership, mutual performance monitoring, backup behaviour, adaptability and team orientation — supported by three coordinating mechanisms: shared mental models, closed-loop communication and mutual trust [14]. This model has proved unusually portable into acute care, and directly underpins the TeamSTEPPS curriculum [15].

Crisis resource management (CRM), adapted from aviation crew resource management by Gaba and colleagues, addresses the specific case of a small team performing a high-consequence task under acute time pressure with incomplete information. Its constructs — role clarity, explicit leadership, global situational awareness, resource mobilisation, workload distribution and the legitimacy of speaking up — map closely onto the demands of intubation, resuscitation and ECMO cannulation [16].

Psychological safety, defined by Edmondson as a shared belief that the team is safe for interpersonal risk-taking, is the emergent state that determines whether junior or lower-status members will voice concern about a deteriorating patient or an erroneous plan [17,18]. In respiratory emergencies, where the person with the most current information (the bedside nurse, the respiratory therapist at the ventilator) is frequently not the person with the most authority, psychological safety is not a soft variable but a determinant of information flow.

Distributed cognition provides the complementary account: the team, together with its artefacts (monitors, checklists, whiteboards, protocol cards, ventilator displays), functions as a single cognitive system. Performance failures can then be located in the system's representational structure — an unshared assumption, an unread alarm, an unspoken plan — rather than exclusively in individual error [19].

3.3 THE COMPOSITION OF THE RESPIRATORY EMERGENCY TEAM

Typical membership, with characteristic contributions:

Role	Core contribution in respiratory emergencies
Intensivist / emergency physician / anaesthetist	Diagnostic formulation, escalation decisions, airway and procedural leadership, goals-of-care discussion
Critical care / emergency nurse	Continuous surveillance, early recognition of deterioration, drug administration, family liaison, procedural assistance

Respiratory therapist / respiratory physiotherapist	Ventilator setup and titration, NIV and HFNC initiation and troubleshooting, airway clearance, weaning protocol execution, arterial blood gas interpretation
Clinical pharmacist	Rapid sequence induction drug selection and dosing, bronchodilator and steroid regimens, sedation and analgesia optimisation, antimicrobial stewardship, renal and hepatic dose adjustment
Physiotherapist	Early mobilisation, secretion clearance, post-extubation rehabilitation
Radiologist / point-of-care ultrasound operator	Chest imaging interpretation, lung and cardiac ultrasound, CTPA reporting in suspected PE
Perfusionist / ECMO specialist	Circuit management, cannulation support, anticoagulation monitoring
Dietitian, speech and language therapist, social worker	Nutrition during ventilation, post-extubation swallow assessment, discharge planning and family support

The functional point is not the length of the list but its implication: the information needed to make a correct and timely decision is never held by one person. Any organisational arrangement that fails to aggregate it reliably will underperform regardless of individual expertise.

4. THE CLINICAL LANDSCAPE OF RESPIRATORY EMERGENCIES

4.1 Acute exacerbation of COPD

Non-invasive ventilation for acute hypercapnic respiratory failure complicating COPD exacerbation reduces intubation rate and mortality, an effect established in randomised trials and confirmed in ward-based implementation [9,10]. Crucially, the benefit demonstrated in trials is contingent on delivery quality — appropriate patient selection, correct interface fitting, adequate initial pressures, close monitoring for failure, and timely escalation to intubation when NIV is not succeeding. Each of these is a team task distributed across nurse, respiratory therapist and physician. Implementation studies have consistently shown outcomes inferior to trial results where these delivery conditions are not met, which is itself indirect evidence for the importance of team process.

4.2 Acute severe asthma and status asthmaticus

Management requires near-simultaneous continuous bronchodilator delivery, systemic corticosteroid administration, magnesium consideration, close respiratory monitoring and preparation for a high-risk intubation should deterioration occur. The peri-intubation period in severe asthma is exceptionally hazardous, with risk of dynamic hyperinflation, hypotension and cardiac arrest. Pre-briefed role allocation and pre-drawn vasopressors are team-level, not individual-level, interventions.

4.3 Severe community-acquired pneumonia and sepsis

Sepsis bundle compliance — timely blood cultures, antimicrobials, lactate measurement and fluid resuscitation — correlates with survival, and bundle compliance is a coordination outcome as much as a clinical one [20,21]. Achieving antimicrobial administration within the first hour in a hypotensive patient with pneumonia requires the recognising nurse, the prescribing physician, the dispensing pharmacist and the administering nurse to operate as a single sequence without queuing delay.

4.4 Acute respiratory distress syndrome

ARDS management is now a multi-component protocol: low tidal volume ventilation, plateau and driving pressure limitation, appropriate PEEP, conservative fluid strategy, neuromuscular blockade in selected severe cases, prone positioning for ≥12–16 hours daily in moderate-to-severe disease, and consideration of ECMO in refractory hypoxaemia [7,8,22,23]. Prone positioning is the clearest example in critical care of an intervention whose safe execution is definitionally a team procedure: it typically requires four to six staff, structured role assignment, airway protection by a designated person, and a rehearsed sequence. Units with established proning teams and checklists report lower rates of tube dislodgement, line loss and pressure injury than those improvising the manoeuvre.

Despite class I evidence, large observational cohorts have documented substantial under-recognition of ARDS and under-use of both lung-protective settings and prone positioning [5]. The gap between evidence and practice in ARDS is largely an organisational gap.

4.5 High-risk pulmonary embolism

Massive and submassive pulmonary embolism requires rapid risk stratification and a reperfusion decision — systemic thrombolysis, catheter-directed therapy, surgical embolectomy or anticoagulation alone — that draws on emergency medicine, critical care, cardiology, interventional radiology, vascular surgery, cardiothoracic surgery and haematology [12,24]. No single specialty routinely commands the full decision space, which is precisely the rationale for the pulmonary embolism response team model described in Section 5.5.

4.6 Refractory respiratory failure requiring ECMO

Veno-venous ECMO for severe ARDS is the most organisationally demanding respiratory intervention in routine practice. It requires 24-hour availability of cannulating proceduralists, perfusion or ECMO-specialist coverage, specifically trained nursing, transfusion and coagulation support, and defined escalation and weaning pathways. Centre volume is associated with mortality, and the volume–outcome relationship is most plausibly explained by accumulated team-level procedural and management competence rather than by any individual operator's caseload [25–27].

4.7 The common structural feature

Across all six presentations the same pattern recurs: the effective intervention is known; its reliable delivery under time pressure is the limiting factor; and reliable delivery is a property of teams. This is the central claim the remainder of the review examines empirically.

5. TEAM MODELS AND THEIR OUTCOME EVIDENCE

5.1 Rapid response and medical emergency teams

Rapid response systems (RRS) — comprising an afferent limb of detection and escalation criteria and an efferent limb of a multidisciplinary response team — were designed explicitly around the observation that in-hospital deterioration, frequently respiratory in origin, is preceded by hours of documented but unactioned abnormal physiology.

The evidence is genuinely mixed and instructive. The MERIT cluster-randomised trial found no significant reduction in the composite primary outcome, though it was complicated by substantial contamination and by improvement in control hospitals [28]. Subsequent meta-analyses have nonetheless found consistent reductions in cardiopulmonary arrest rates outside the ICU, with more variable and generally smaller effects on hospital mortality [29,30]. The most defensible reading is that rapid response systems reliably reduce the events they are designed to prevent, that translation to mortality depends on baseline arrest rates and on the maturity of the afferent limb, and that the afferent limb — the culture and authority permitting a junior nurse to escalate — is more determinative than the composition of the responding team.

Early warning scores such as NEWS/NEWS2 and machine-learning derived deterioration models have improved the sensitivity of the afferent limb [31–33]. However, detection without a functioning escalation culture produces alarm burden rather than benefit — a finding that reinforces the teamwork rather than technology reading of the evidence.

5.2 Structured airway and intubation teams

Tracheal intubation of the critically ill patient carries a complication rate an order of magnitude higher than elective theatre intubation, with hypoxaemia, hypotension, cardiac arrest and oesophageal intubation all substantially more frequent. The Fourth National Audit Project identified failures of planning, communication and escalation — not solely technical failure — as recurrent contributors to major airway complications outside the operating theatre [34].

The response has been explicitly team-based. Intubation care bundles combining pre-procedure preparation, two-operator presence, fluid loading, rapid sequence induction, capnography and post-intubation checks have been associated with reductions in life-threatening complications [35]. Difficult Airway Society guidelines for the critically ill adult formalise team-level elements: a pre-intubation checklist read aloud, explicit nomination of an intubator, an assistant, a drug administrator and a person responsible for calling out vital signs; a verbalised plan A through D; and a designated declaration point for front-of-neck access

[36,37]. The Vortex approach was designed principally to give the *whole team* a shared cognitive model of airway escalation rather than to give the intubator a new technique [38].

Observational and before–after evaluations of intubation checklists and pre-procedure team briefings report improved first-pass success and reduced peri-intubation desaturation and hypotension, although randomised evidence for checklists alone in isolation from other bundle elements is less consistent. The interpretive point is that the checklist functions as a device for constructing a shared mental model, and is unlikely to produce benefit where it is completed silently by one person.

5.3 Respiratory-therapist- and nurse-driven ventilator liberation

This is arguably the strongest evidence in the entire field, because it involves randomised trials of an explicitly transdisciplinary reallocation of decision authority.

Daily identification of patients capable of spontaneous breathing, with protocolised spontaneous breathing trials conducted by nurses and respiratory therapists, shortened duration of mechanical ventilation compared with conventional physician-directed practice [11]. Protocol-directed weaning executed by non-physician staff produced comparable results in independent trials [39]. Paired sedation interruption and spontaneous breathing trials — the Awakening and Breathing Controlled protocol, requiring tight nurse–respiratory therapist coordination — reduced ventilator days and, notably, one-year mortality [40]. The Cochrane synthesis confirmed reductions in ventilation duration, weaning duration and ICU length of stay with protocolised weaning [41].

Extension of this logic into the ABCDEF (ICU Liberation) bundle — assess and manage pain, both spontaneous awakening and breathing trials, choice of sedation, delirium monitoring, early mobility, family engagement — has been associated in large prospective cohorts with dose-dependent reductions in mortality, mechanical ventilation, delirium, restraint use and ICU readmission [42,43]. The bundle cannot be executed by any single profession; its performance is a direct index of interprofessional coordination, and the dose–response relationship between bundle compliance and outcome is among the most persuasive available evidence that coordination itself carries clinical value.

5.4 Interprofessional ICU rounds and daily goals

Structured interprofessional rounding with an explicit daily goals instrument improves clarity about the plan of care among nurses and residents and has been associated with reduced ICU length of stay [44,45]. In a large observational analysis, multidisciplinary care team management was associated with lower 30-day mortality in medical ICU patients, with the association strongest in units with high-intensity physician staffing [46]. Broader reviews of ICU physician staffing organisation likewise associate high-intensity models with lower mortality and length of stay, though nighttime intensivist staffing specifically did not improve outcomes in a randomised trial conducted in units already having daytime intensivist coverage — a finding consistent with diminishing returns once organisational maturity is achieved [47–49].

5.5 Pulmonary embolism response teams

The PERT model convenes a multidisciplinary group in real time — typically by a single activation call generating a rapid virtual conference among emergency medicine, critical care, cardiology, interventional radiology, vascular medicine, haematology and cardiothoracic surgery — to make a consensus reperfusion decision for high-risk PE [24,50]. Reported effects across observational and registry evidence include shortened time to definitive therapy, increased use of advanced therapies in appropriately selected patients, reduced major bleeding relative to historical thrombolysis practice, and in some series reduced mortality. The evidence is predominantly before–after and registry-based, with attendant confounding by secular trend and by improvement in catheter technology over the same period. Nonetheless, PERT is the clearest contemporary example of a team model created specifically to solve a *decision-coordination* problem rather than a *task-execution* problem, and its rapid international adoption reflects a widely felt organisational need.

5.6 ECMO teams and the volume–outcome relationship

The CESAR trial demonstrated benefit from *referral to an ECMO centre* rather than from ECMO per se, which is itself a statement about organisational capability [26]. EOLIA did not meet its primary endpoint but, with subsequent Bayesian reanalysis and meta-analysis, supports benefit in severe ARDS when delivered in experienced centres [27,51]. Registry analyses associate higher annual centre volume with lower mortality [25]. Given that ECMO management involves continuous coordination among intensivist, ECMO specialist, perfusionist, nurse, surgeon and transfusion service across days to weeks, centre-level effects are difficult to attribute to any individual operator and are most plausibly team- and system-level phenomena.

5.7 Prehospital and interface teams

Transitions — prehospital to emergency department, emergency department to ICU, ICU to ward — are recognised high-risk points for information loss. Structured handover formats improve information transfer, and the I-PASS handover bundle reduced medical errors and preventable adverse events in a large multicentre paediatric study, with the effect attributable to the structured verbal and written protocol rather than to any change in clinical staffing [52]. SBAR and its variants remain the most widely adopted structured escalation format in acute respiratory deterioration, principally because it compresses an unstructured clinical narrative into a form that reliably conveys urgency across professional and hierarchical boundaries [53].

5.8 Tele-critical care

Remote intensivist and tele-ICU support represents an extension of the team beyond physical co-location. A large before–after study reported reductions in hospital mortality and length of stay following tele-ICU implementation with associated care standardisation [54], and meta-analysis has associated telemedicine in critical care with reduced ICU mortality and ICU length of stay, with weaker effects on hospital-level outcomes [55]. The effects appear mediated largely by improved protocol adherence and faster escalation — that is, by the same teamwork mechanisms operating at a distance. Tele-critical care is of particular interest for respiratory emergencies in resource-limited and rural settings, where local multidisciplinary depth is limited.

6. PATIENT OUTCOME DOMAINS

Synthesising across the models above, the outcome domains in which multidisciplinary teamwork has demonstrated or plausible effect can be organised as follows.

Mortality. Effects are demonstrable but generally modest and inconsistently reproduced. They are most convincingly shown where the team intervention alters delivery of a therapy with an established mortality benefit — paired sedation and breathing trials, ICU Liberation bundle compliance, sepsis bundle compliance, referral to high-volume ECMO centres. They are least convincingly shown where the intervention is generic team training without a specific clinical delivery target, although a meta-analysis of team training in healthcare found meaningful associations with both clinical process and patient outcomes across settings [56].

Duration of mechanical ventilation and ventilator-free days. The most robust domain, supported by randomised evidence for protocolised, non-physician-driven weaning [11,39–41]. Reductions of approximately one to two days are typical, with corresponding reductions in ventilator-associated complications.

ICU and hospital length of stay. Consistently reduced across protocolised weaning trials, structured rounding studies and tele-ICU evaluations, though estimates are vulnerable to discharge-practice confounding.

Cardiopulmonary arrest and unplanned ICU admission. Reduced by mature rapid response systems, the most reproducible finding in that literature [29,30].

Procedural safety endpoints. First-pass intubation success, peri-intubation hypoxaemia and hypotension, oesophageal intubation, unplanned extubation, line and tube dislodgement during proning. These are the endpoints most directly and immediately sensitive to team process, and consequently the most useful for evaluating team interventions in modestly sized studies.

Guideline and bundle adherence. Best understood as an intermediate outcome and as the principal mediating variable. Bundle compliance is measurable at scale, responds rapidly to team intervention, and has a documented dose–response relationship with patient outcomes [42,43].

Delirium, restraint use and functional recovery. Reduced by ABCDEF bundle implementation, with implications for long-term cognitive and physical outcomes among survivors of respiratory failure [42,43].

Family and patient experience. Interprofessional family communication interventions and family-centred care practices improve family-reported quality of communication and reduce family symptoms of anxiety and depression, though effects on family psychological outcomes have been inconsistent across randomised trials [57,58].

Readmission and post-acute outcomes. Multidisciplinary discharge bundles for COPD, integrating pharmacist medication review, inhaler technique teaching, smoking cessation referral, pulmonary rehabilitation referral and early follow-up, have been associated with reduced 30-day readmission, though results across trials are heterogeneous and sensitive to health system context.

Staff outcomes as a mediating pathway. Team functioning is associated with burnout, moral distress and intent to leave among critical care staff [59,60]. Since emotional exhaustion and workload predict both clinician-rated and objectively measured patient safety [61], workforce wellbeing is best modelled as a mediator on the causal path between team functioning and patient outcome, not as a separate endpoint.

7. MECHANISMS: HOW TEAMWORK BECOMES OUTCOME

A recurrent weakness of the literature is treatment of "teamwork" as an undifferentiated exposure. Specifying mechanism improves both interpretation and intervention design.

7.1 Shared mental models

A shared mental model is a common representation of the patient's problem, the plan, the anticipated trajectory and each member's role. In a respiratory emergency, the practical question is whether every member of the team can answer: what is wrong, what are we doing, what happens if it fails, and what is my task. Verbalised plans, pre-procedure briefings and read-aloud checklists exist to construct this shared representation. Where it is absent, characteristic failures follow: the assistant not anticipating the need for a bougie, the nurse not recognising that a falling saturation has crossed the threshold for plan B, the second physician unaware that front-of-neck access has become the next step.

7.2 Closed-loop communication

Directed, acknowledged and confirmed communication — naming the recipient, stating the instruction, receiving explicit acknowledgement, confirming completion. Simulation research in resuscitation has associated leadership behaviour and explicit task allocation with measurable improvements in performance quality, including chest compression parameters and time to critical interventions [62,63]. In respiratory emergencies the equivalent failures are drug dose errors, unadministered medications and undelivered escalation calls.

7.3 Explicit role allocation and leadership

Diffusion of responsibility is a well-documented failure mode in unstructured teams: the more people present, the longer critical tasks may go unperformed. Explicit nomination — "you are on airway, you are on drugs, you are timekeeping, you are documenting" — converts a crowd into a team. This is the single most trainable and highest-yield behavioural element in acute respiratory events.

7.4 Psychological safety and speaking up

The bedside nurse who has watched the patient for eight hours and the respiratory therapist adjusting the ventilator frequently hold decisive information. Whether it reaches the decision-maker depends on hierarchy gradient, prior experience of how concerns are received, and whether an explicit invitation to voice concern has been issued [17,18]. Graded assertiveness scripts (PACE, CUS) exist to lower the interpersonal cost of escalation. Their utility depends on senior clinicians reliably responding well when they are used.

7.5 Distributed cognitive load and mutual performance monitoring

Under time pressure, individual working memory is the binding constraint. Teams manage this by distributing tasks, externalising information into artefacts (checklists, whiteboards, protocol cards, monitor displays) and cross-monitoring for slips. Cognitive aids for emergencies function by offloading recall so that attention can be spent on judgement.

7.6 Structured information transfer

Handover formats (SBAR, ISBAR, I-PASS) and structured rounds (daily goals) reduce the entropy of information transfer across shifts, units and professions [44,52,53]. Their contribution is disproportionately large in respiratory failure, where trajectory over hours — the ventilator settings tried, the response to each, the escalation threshold agreed — carries most of the clinically relevant information.

7.7 Standardisation as a coordination technology

Protocols are frequently framed as constraints on clinical autonomy. Functionally, they are coordination devices: they allow each member to predict what others will do without negotiating it in real time. This is why protocolised weaning outperforms individualised physician-directed weaning despite the latter's theoretical capacity for tailoring — the coordination gain exceeds the personalisation loss [11,39,41].

8. BARRIERS AND ENABLERS

8.1 Barriers

Hierarchical and professional boundaries. Longstanding status differentials between medicine, nursing and allied health suppress information flow. Professional identity ("tribalism") can convert coordination problems into jurisdictional disputes [64].

Staffing adequacy. Team process cannot compensate indefinitely for insufficient staff. Nurse staffing levels are independently associated with mortality across large multinational studies [65,66]; below a threshold, no amount of teamwork training will produce reliable surveillance of a deteriorating respiratory patient.

Burnout and turnover. High rates of burnout among critical care staff degrade both individual performance and team stability; high turnover destroys the accumulated implicit coordination that distinguishes an experienced team from a newly assembled one [59–61].

Ad hoc team composition. Emergency respiratory events are frequently managed by teams that have never worked together, assembled minutes before, sometimes without knowing each other's names or grades. This is the modal condition in the emergency department and on general wards at night, and it argues strongly for standardised roles and explicit briefings, since implicit coordination is unavailable.

Physical and informational environment. Poorly designed resuscitation spaces, inconsistent equipment layout across units, and electronic records that fragment rather than aggregate the respiratory trajectory all impose avoidable coordination cost.

Training silos. Professions are educated separately and then expected to perform interdependently. Interprofessional education addresses this in principle, though the Cochrane evidence for downstream effects on patient outcomes remains limited by study quality and quantity [67,68].

8.2 Enablers

Institutional leadership and psychological safety at unit level. The most consistent finding in implementation research is that unit-level leadership behaviour predicts whether a team intervention takes root.

In-situ simulation. Rehearsal in the actual clinical environment with the actual team identifies latent system failures — missing equipment, unclear escalation numbers, ambiguous role boundaries — that classroom training cannot. Simulation-based education is associated with improved skill and process outcomes, with more limited but real evidence for patient outcome effects [69,70].

Structured team training programmes. TeamSTEPPS and CRM-derived curricula have been associated with improvements in team behaviour and, in surgical settings, with mortality reduction where implementation was systematic and sustained [15,71]. Meta-analytic evidence supports transfer to clinical process and patient outcomes [56].

Protocolisation and checklists as coordination technologies, as discussed above.

Measurement and feedback. Units that measure bundle compliance and feed it back visibly improve; those that do not, drift.

Deliberate team stability where rostering permits, since familiarity reduces coordination cost.

9. MEASUREMENT AND METHODOLOGICAL CHALLENGES

9.1 Instruments for team performance

Several validated observational instruments exist, developed largely in resuscitation and surgical contexts and transferable to respiratory emergencies:

- **TEAM (Team Emergency Assessment Measure)** — an 11-item observational scale for emergency team performance covering leadership, teamwork and task management, with good psychometric properties [72].
- **OSCAR (Observational Skill-based Clinical Assessment tool for Resuscitation)** — assesses communication, cooperation, coordination, leadership, monitoring and decision-making across professional subgroups [73].

- **Ottawa Global Rating Scale** — CRM-oriented, used widely in simulation.
- **T-TPQ (TeamSTEPPS Teamwork Perceptions Questionnaire)** — self-report measure of perceived team functioning.
- **Safety Attitudes Questionnaire** — unit-level climate measure frequently used as a proxy.

Each measures something different — observed behaviour, perceived climate, self-reported attitude — and they correlate imperfectly. Studies should state which construct they intend.

9.2 Design limitations of the evidence base

Predominance of before–after designs. Most team interventions are evaluated as uncontrolled before–after studies, which cannot separate the intervention from secular improvement, Hawthorne effects or co-interventions. Given that critical care outcomes have improved steadily over the study period for multiple unrelated reasons, this is a serious confound.

Contamination in cluster trials. MERIT illustrates the problem: control hospitals adopted elements of the intervention, and both arms improved [28]. Team interventions diffuse readily, which biases cluster trials towards the null.

Blinding is impossible. Neither participants nor outcome assessors can be blinded to the presence of a team intervention, inflating risk of performance and detection bias for subjective outcomes.

Complex intervention attribution. Bundles are, by construction, multi-component. Whether benefit derives from the individual components, from their combination, or from the organisational attention that implementation attracts is rarely separable.

Outcome heterogeneity. "Length of stay" may be measured from admission, from intubation, or from ICU arrival; mortality at ICU discharge, hospital discharge, 28 days, 90 days or one year. Comparability across studies is poor, and a core outcome set for team interventions in critical care does not yet exist.

Publication and implementation bias. Positive implementations are published; failed implementations, which would be more informative about the boundary conditions of effect, generally are not.

Baseline-dependence of effect. The effect of a team intervention is a function of the gap between current and achievable performance. A unit with excellent baseline coordination will show little benefit; the same intervention in a poorly coordinated unit may show large benefit. This makes pooled effect estimates difficult to interpret and partially explains the heterogeneity across studies. It is a substantive property of the intervention, not merely statistical noise.

9.3 What better studies would look like

Adequately powered stepped-wedge cluster-randomised designs; explicit measurement of team process as a mediator rather than inference from outcomes alone; pre-specified implementation fidelity measures; standardised outcome definitions; reporting of failed implementations; and mixed-methods designs capable of explaining why an intervention succeeded in one unit and failed in another.

10. IMPLEMENTATION STRATEGIES

Translation of the evidence into practice can be organised into five actionable domains.

1. Define roles explicitly and in advance. Named roles for respiratory emergencies — team leader, airway operator, airway assistant, drugs, circulation and vascular access, monitoring and callout, documentation, family liaison — assigned verbally at the outset of every event and, where feasible, indicated by role tabards. This is low cost, requires no new staff and addresses the most common failure mode in ad hoc teams.

2. Standardise the high-risk sequences. Pre-intubation checklists read aloud, proning checklists with named positions, NIV initiation and failure-escalation protocols with explicit time-bound review points, ECMO cannulation checklists. The standardisation should specify not only the tasks but who performs each.

3. Train the team as a team, in situ. Regular short in-situ simulations of respiratory emergency scenarios — failed NIV, difficult airway in the ICU, deterioration during proning, ECMO circuit emergency — involving the actual multidisciplinary staff of the unit, with structured debriefing focused on coordination rather than clinical knowledge. Latent system failures identified during these sessions should be logged and remediated.

4. Structure the information architecture. A single agreed handover format; interprofessional rounds with a daily goals instrument that every member can see; visible display of ventilator trajectory, bundle compliance and escalation thresholds; escalation criteria that are explicit and unambiguous.

5. Measure, feed back and protect psychological safety. Track bundle compliance, first-pass intubation success, peri-intubation complications, time from deterioration to escalation, and proning-related adverse events. Feed these back at unit level without individual attribution. Debrief real events, not only simulated ones. Respond visibly and constructively when staff escalate concerns, since a single dismissive response can suppress escalation across a unit for months.

11. RESEARCH GAPS AND FUTURE DIRECTIONS

Cluster-randomised evidence. The field needs a small number of large, well-conducted stepped-wedge trials of defined team interventions in respiratory emergencies, with mediation analysis linking team process measures to patient endpoints.

A core outcome set. Consensus definitions for team-intervention studies in acute respiratory care, spanning process, patient and staff domains, would allow synthesis that is currently impossible.

Low- and middle-income settings. The overwhelming majority of the evidence originates in high-income health systems with respiratory therapists, high nurse-to-patient ratios and intensivist coverage. Global critical care need is concentrated elsewhere [74–76]. Which team interventions retain effect under different staffing structures, and which are contingent on resources unavailable in most of the world, is largely unstudied and is arguably the most important open question in the field.

Ad hoc and virtual teams. Increasing use of tele-critical care, locum and agency staffing, and cross-covering arrangements means that the stable co-located team assumed by most of the theoretical literature is becoming less typical. Coordination mechanisms for teams that lack familiarity and co-presence need dedicated study.

Surge and pandemic conditions. The COVID-19 pandemic produced large-scale natural experiments in team reconfiguration — redeployment of non-critical-care staff, proning teams, airway teams, tiered staffing models — that remain incompletely analysed [77,78]. The determinants of team performance under sustained surge differ from those under normal conditions and warrant separate characterisation.

Artificial intelligence and decision support as team members. Automated deterioration prediction is already deployed at scale [33]. How predictive alerts are integrated into team decision-making — who receives them, who is accountable for acting, how they interact with clinician judgement and with alarm fatigue — is a teamwork question that is currently being answered by default rather than by design.

Longer-horizon outcomes. Most studies stop at hospital discharge. Whether team quality during the acute respiratory event influences post-intensive-care syndrome, functional recovery, return to work and one-year quality of life among survivors is essentially unexamined.

12. CONCLUSION

Across rapid response systems, protocolised ventilator liberation, structured airway management, pulmonary embolism response teams, ECMO programmes and interprofessional ICU rounding, the evidence converges on a consistent proposition: in respiratory emergencies, the organisation of multidisciplinary work is a determinant of patient outcome, and not merely a background condition of care delivery.

The effect is not uniform and should not be overstated. Mortality reductions attributable specifically to team interventions are modest, inconsistently reproduced and heavily conditioned by baseline performance and implementation fidelity. The strongest and most reproducible effects are on duration of mechanical ventilation, length of stay, procedural safety endpoints and adherence to interventions of proven benefit. The mortality signal, where present, is generally traceable through those intermediate outcomes.

The mechanism is reasonably well characterised. Teamwork acts through shared mental models, closed-loop communication, explicit role allocation, psychological safety, distributed cognitive load and structured information transfer. These are specific, teachable and measurable behaviours, not general dispositions. Interventions that target them directly — checklists read aloud, briefings, named roles, in-situ simulation, structured handover, protocols as coordination devices — have better evidence than generic exhortations to collaborate.

The practical implication for clinical services is that investment in team structure and team training should be evaluated on the same terms as investment in drugs and devices. In a domain where the therapeutic evidence is mature and the delivery gap is wide, the marginal return on improving coordination is likely to exceed the marginal return on further therapeutic novelty. The principal obstacles are not conceptual but organisational: staffing adequacy, hierarchy, training silos, workforce instability and the absence of routine measurement of team process.

The principal research obligation is to close the evidential gap between what is plausible and what is demonstrated, through randomised or quasi-experimental designs with explicit mediation analysis, standardised outcomes, honest reporting of failed implementations, and — most urgently — evaluation in the resource-constrained settings where most of the world's respiratory emergencies are actually managed.

References

1. Kohn LT, Corrigan JM, Donaldson MS, eds. *To Err Is Human: Building a Safer Health System*. Washington, DC: National Academy Press; 2000.

2. Leonard M, Graham S, Bonacum D. The human factor: the critical importance of teamwork and communication in providing safe care. *Qual Saf Health Care*. 2004;13(Suppl 1):i85–i90.

3. Global Initiative for Chronic Obstructive Lung Disease (GOLD). *Global Strategy for the Diagnosis, Management, and Prevention of COPD*. 2024 Report.

4. Vincent JL, Sakr Y, Singer M, et al. Prevalence and outcomes of infection among patients in intensive care units. *JAMA*. 2020;323(15):1478–1487.

5. Bellani G, Laffey JG, Pham T, et al. Epidemiology, patterns of care, and mortality for patients with acute respiratory distress syndrome in intensive care units in 50 countries (LUNG SAFE). *JAMA*. 2016;315(8):788–800.

6. Ferguson ND, Fan E, Camporota L, et al. The Berlin definition of ARDS: an expanded rationale, justification, and supplementary material. *Intensive Care Med*. 2012;38(10):1573–1582.

7. Acute Respiratory Distress Syndrome Network. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. *N Engl J Med*. 2000;342(18):1301–1308.

8. Guérin C, Reignier J, Richard JC, et al. Prone positioning in severe acute respiratory distress syndrome (PROSEVA). *N Engl J Med*. 2013;368(23):2159–2168.

9. Brochard L, Mancebo J, Wysocki M, et al. Noninvasive ventilation for acute exacerbations of chronic obstructive pulmonary disease. *N Engl J Med*. 1995;333(13):817–822.

10. Plant PK, Owen JL, Elliott MW. Early use of non-invasive ventilation for acute exacerbations of chronic obstructive pulmonary disease on general respiratory wards: a multicentre randomised controlled trial. *Lancet*. 2000;355(9219):1931–1935.

11. Ely EW, Baker AM, Dunagan DP, et al. Effect on the duration of mechanical ventilation of identifying patients capable of breathing spontaneously. *N Engl J Med*. 1996;335(25):1864–1869.

12. Konstantinides SV, Meyer G, Becattini C, et al. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism. *Eur Heart J*. 2020;41(4):543–603.

13. Global Initiative for Asthma (GINA). *Global Strategy for Asthma Management and Prevention*. 2024 Update.

14. Salas E, Sims DE, Burke CS. Is there a "Big Five" in teamwork? *Small Group Res*. 2005;36(5):555–599.

15. King HB, Battles J, Baker DP, et al. TeamSTEPPS: team strategies and tools to enhance performance and patient safety. In: *Advances in Patient Safety: New Directions and Alternative Approaches*. Rockville, MD: AHRQ; 2008.

16. Gaba DM, Fish KJ, Howard SK, Burden A. *Crisis Management in Anesthesiology*. 2nd ed. Philadelphia: Elsevier; 2015.

17. Edmondson A. Psychological safety and learning behavior in work teams. *Adm Sci Q*. 1999;44(2):350–383.

18. Nembhard IM, Edmondson AC. Making it safe: the effects of leader inclusiveness and professional status on psychological safety and improvement efforts in health care teams. *J Organ Behav*. 2006;27(7):941–966.

19. Hutchins E. *Cognition in the Wild*. Cambridge, MA: MIT Press; 1995.

20. Rhodes A, Evans LE, Alhazzani W, et al. Surviving Sepsis Campaign: international guidelines for management of sepsis and septic shock: 2016. *Intensive Care Med*. 2017;43(3):304–377.

21. Levy MM, Rhodes A, Phillips GS, et al. Surviving Sepsis Campaign: association between performance metrics and outcomes in a 7.5-year study. *Intensive Care Med*. 2014;40(11):1623–1633.

22. Fan E, Del Sorbo L, Goligher EC, et al. An official ATS/ESICM/SCCM clinical practice guideline: mechanical ventilation in adult patients with acute respiratory distress syndrome. *Am J Respir Crit Care Med*. 2017;195(9):1253–1263.

23. Papazian L, Forel JM, Gacouin A, et al. Neuromuscular blockers in early acute respiratory distress syndrome. *N Engl J Med*. 2010;363(12):1107–1116.

24. Kabrhel C, Rosovsky R, Channick R, et al. A multidisciplinary pulmonary embolism response team: initial 30-month experience with a novel approach to delivery of care to patients with submassive and massive pulmonary embolism. *Chest*. 2016;150(2):384–393.

25. Barbaro RP, Odetola FO, Kidwell KM, et al. Association of hospital-level volume of extracorporeal membrane oxygenation cases and mortality. *Am J Respir Crit Care Med*. 2015;191(8):894–901.

26. Peek GJ, Mugford M, Tiruvoipati R, et al. Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR). *Lancet*. 2009;374(9698):1351–1363.

27. Combes A, Hajage D, Capellier G, et al. Extracorporeal membrane oxygenation for severe acute respiratory distress syndrome (EOLIA). *N Engl J Med*. 2018;378(21):1965–1975.

28. Hillman K, Chen J, Cretikos M, et al. Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial. *Lancet*. 2005;365(9477):2091–2097.

29. Chan PS, Jain R, Nallmothu BK, Berg RA, Sasson C. Rapid response teams: a systematic review and meta-analysis. *Arch Intern Med*. 2010;170(1):18–26.

30. Maharaj R, Raffaele I, Wendon J. Rapid response systems: a systematic review and meta-analysis. *Crit Care*. 2015;19:254.

31. Smith GB, Prytherch DR, Meredith P, Schmidt PE, Featherstone PI. The ability of the National Early Warning Score (NEWS) to discriminate patients at risk of early cardiac arrest, unanticipated intensive care unit admission, and death. *Resuscitation*. 2013;84(4):465–470.

32. Churpek MM, Yuen TC, Winslow C, et al. Multicenter development and validation of a risk stratification tool for ward patients. *Am J Respir Crit Care Med*. 2014;190(6):649–655.

33. Escobar GJ, Liu VX, Schuler A, et al. Automated identification of adults at risk for in-hospital clinical deterioration. *N Engl J Med*. 2020;383(20):1951–1960.

34. Cook TM, Woodall N, Frerk C. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. *Br J Anaesth*. 2011;106(5):617–631.

35. Jaber S, Jung B, Corne P, et al. An intervention to decrease complications related to endotracheal intubation in the intensive care unit: a prospective, multiple-center study. *Intensive Care Med*. 2010;36(2):248–255.

36. Higgs A, McGrath BA, Goddard C, et al. Guidelines for the management of tracheal intubation in critically ill adults. *Br J Anaesth*. 2018;120(2):323–352.

37. Frerk C, Mitchell VS, McNarry AF, et al. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. *Br J Anaesth*. 2015;115(6):827–848.

38. Chrimes N. The Vortex: a universal 'high-acuity implementation tool' for emergency airway management. *Br J Anaesth*. 2016;117(Suppl 1):i20–i27.

39. Kollef MH, Shapiro SD, Silver P, et al. A randomized, controlled trial of protocol-directed versus physician-directed weaning from mechanical ventilation. *Crit Care Med*. 1997;25(4):567–574.

40. Girard TD, Kress JP, Fuchs BD, et al. Efficacy and safety of a paired sedation and ventilator weaning protocol for mechanically ventilated patients in intensive care (Awakening and Breathing Controlled trial). *Lancet*. 2008;371(9607):126–134.

41. Blackwood B, Alderdice F, Burns K, et al. Use of weaning protocols for reducing duration of mechanical ventilation in critically ill adult patients: Cochrane systematic review and meta-analysis. *BMJ*. 2011;342:c7237.

42. Balas MC, Vasilevskis EE, Olsen KM, et al. Effectiveness and safety of the awakening and breathing coordination, delirium monitoring/management, and early exercise/mobility bundle. *Crit Care Med*. 2014;42(5):1024–1036.

43. Pun BT, Balas MC, Barnes-Daly MA, et al. Caring for critically ill patients with the ABCDEF bundle: results of the ICU Liberation Collaborative in over 15,000 adults. *Crit Care Med*. 2019;47(1):3–14.

44. Pronovost P, Berenholtz S, Dorman T, Lipsett PA, Simmonds T, Haraden C. Improving communication in the ICU using daily goals. *J Crit Care*. 2003;18(2):71–75.

45. Vazirani S, Hays RD, Shapiro MF, Cowan M. Effect of a multidisciplinary intervention on communication and collaboration among physicians and nurses. *Am J Crit Care*. 2005;14(1):71–77.

46. Kim MM, Barnato AE, Angus DC, Fleisher LA, Kahn JM. The effect of multidisciplinary care teams on intensive care unit mortality. *Arch Intern Med*. 2010;170(4):369–376.

47. Pronovost PJ, Angus DC, Dorman T, Robinson KA, Dremsizov TT, Young TL. Physician staffing patterns and clinical outcomes in critically ill patients: a systematic review. *JAMA*. 2002;288(17):2151–2162.

48. Wilcox ME, Chong CA, Niven DJ, et al. Do intensivist staffing patterns influence hospital mortality following ICU admission? A systematic review and meta-analyses. *Crit Care Med*. 2013;41(10):2253–2274.

49. Kerlin MP, Small DS, Cooney E, et al. A randomized trial of nighttime physician staffing in an intensive care unit. *N Engl J Med*. 2013;368(23):2201–2209.

50. Rosovsky R, Zhao K, Sista A, Rivera-Lebron B, Kabrhel C. Pulmonary embolism response teams: purpose, evidence for efficacy, and future research directions. *Res Pract Thromb Haemost*. 2019;3(3):315–330.

51. Munshi L, Walkey A, Goligher E, Pham T, Uleryk EM, Fan E. Venovenous extracorporeal membrane oxygenation for acute respiratory distress syndrome: a systematic review and meta-analysis. *Lancet Respir Med*. 2019;7(2):163–172.

52. Starmer AJ, Spector ND, Srivastava R, et al. Changes in medical errors after implementation of a handoff program (I-PASS). *N Engl J Med*. 2014;371(19):1803–1812.

53. Haig KM, Sutton S, Whittington J. SBAR: a shared mental model for improving communication between clinicians. *Jt Comm J Qual Patient Saf*. 2006;32(3):167–175.

54. Lilly CM, Cody S, Zhao H, et al. Hospital mortality, length of stay, and preventable complications among critically ill patients before and after tele-ICU reengineering of critical care processes. *JAMA*. 2011;305(21):2175–2183.

55. Wilcox ME, Adhikari NKJ. The effect of telemedicine in critically ill patients: systematic review and meta-analysis. *Crit Care*. 2012;16(4):R127.

56. Hughes AM, Gregory ME, Joseph DL, et al. Saving lives: a meta-analysis of team training in healthcare. *J Appl Psychol*. 2016;101(9):1266–1304.

57. Davidson JE, Aslakson RA, Long AC, et al. Guidelines for family-centered care in the neonatal, pediatric, and adult ICU. *Crit Care Med*. 2017;45(1):103–128.

58. Curtis JR, Treece PD, Nielsen EL, et al. Randomized trial of communication facilitators to reduce family distress and intensity of end-of-life care. *Am J Respir Crit Care Med*. 2016;193(2):154–162.

59. Poncet MC, Toullic P, Papazian L, et al. Burnout syndrome in critical care nursing staff. *Am J Respir Crit Care Med*. 2007;175(7):698–704.

60. Moss M, Good VS, Gozal D, Kleinpell R, Sessler CN. An official critical care societies collaborative statement: burnout syndrome in critical care healthcare professionals. *Crit Care Med*. 2016;44(7):1414–1421.

61. Welp A, Meier LL, Manser T. Emotional exhaustion and workload predict clinician-rated and objective patient safety. *Front Psychol*. 2015;5:1573.

62. Hunziker S, Johansson AC, Tschan F, et al. Teamwork and leadership in cardiopulmonary resuscitation. *J Am Coll Cardiol*. 2011;57(24):2381–2388.

63. Marsch SC, Müller C, Marquardt K, Conrad G, Tschan F, Hunziker PR. Human factors affect the quality of cardiopulmonary resuscitation in simulated cardiac arrests. *Resuscitation*. 2004;60(1):51–56.

64. Weller J, Boyd M, Cumin D. Teams, tribes and patient safety: overcoming barriers to effective teamwork in healthcare. *Postgrad Med J*. 2014;90(1061):149–154.

65. Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA*. 2002;288(16):1987–1993.

66. Aiken LH, Sloane DM, Bruyneel L, et al. Nurse staffing and education and hospital mortality in nine European countries: a retrospective observational study. *Lancet*. 2014;383(9931):1824–1830.

67. Reeves S, Perrier L, Goldman J, Freeth D, Zwarenstein M. Interprofessional education: effects on professional practice and healthcare outcomes. *Cochrane Database Syst Rev*. 2013;(3):CD002213.

68. Zwarenstein M, Goldman J, Reeves S. Interprofessional collaboration: effects of practice-based interventions on professional practice and healthcare outcomes. *Cochrane Database Syst Rev*. 2009;(3):CD000072.

69. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. *JAMA*. 2011;306(9):978–988.

70. Boet S, Bould MD, Fung L, et al. Transfer of learning and patient outcome in simulated crisis resource management: a systematic review. *Can J Anaesth*. 2014;61(6):571–582.

71. Neily J, Mills PD, Young-Xu Y, et al. Association between implementation of a medical team training program and surgical mortality. *JAMA*. 2010;304(15):1693–1700.

72. Cooper S, Cant R, Porter J, et al. Rating medical emergency teamwork performance: development of the Team Emergency Assessment Measure (TEAM). *Resuscitation*. 2010;81(4):446–452.

73. Walker S, Brett S, McKay A, Lambden S, Vincent C, Sevdalis N. Observational Skill-based Clinical Assessment tool for Resuscitation (OSCAR): development and validation. *Resuscitation*. 2011;82(7):835–844.

74. Adhikari NKJ, Fowler RA, Bhagwanjee S, Rubenfeld GD. Critical care and the global burden of critical illness in adults. *Lancet*. 2010;376(9749):1339–1346.

75. Murthy S, Leligdowicz A, Adhikari NKJ. Intensive care unit capacity in low-income countries: a systematic review. *PLoS One*. 2015;10(1):e0116949.

76. Andrews B, Semler MW, Muchemwa L, et al. Effect of an early resuscitation protocol on in-hospital mortality among adults with sepsis and hypotension: a randomized clinical trial. *JAMA*. 2017;318(13):1233–1240.

77. Grasselli G, Zangrillo A, Zanella A, et al. Baseline characteristics and outcomes of 1591 patients infected with SARS-CoV-2 admitted to ICUs of the Lombardy region, Italy. *JAMA*. 2020;323(16):1574–1581.

78. RECOVERY Collaborative Group. Dexamethasone in hospitalized patients with Covid-19. *N Engl J Med*. 2021;384(8):693–704.

79. Rosen MA, DiazGranados D, Dietz AS, et al. Teamwork in healthcare: key discoveries enabling safer, high-quality care. *Am Psychol*. 2018;73(4):433–450.

80. Dietz AS, Pronovost PJ, Mendez-Tellez PA, et al. A systematic review of teamwork in the intensive care unit: what do we know about teamwork, team tasks, and improvement strategies? *J Crit Care*. 2014;29(6):908–914.

81. Manser T. Teamwork and patient safety in dynamic domains of healthcare: a review of the literature. *Acta Anaesthesiol Scand*. 2009;53(2):143–151.

82. Reader TW, Flin R, Mearns K, Cuthbertson BH. Developing a team performance framework for the intensive care unit. *Crit Care Med*. 2009;37(5):1787–1793.

83. Donovan AL, Aldrich JM, Gross AK, et al. Interprofessional care and teamwork in the ICU. *Crit Care Med*. 2018;46(6):980–990.

84. Schmutz JB, Meier LL, Manser T. How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: a systematic review and meta-analysis. *BMJ Open*. 2019;9(9):e028280.

85. Buljac-Samardzic M, Doekhie KD, van Wijngaarden JDH. Interventions to improve team effectiveness within health care: a systematic review of the past decade. *Hum Resour Health*. 2020;18:2.