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The Society of Critical Care Medicine at 50 Years: Interprofessional Practice in Critical Care: Looking Back and Forging Ahead

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OVERVIEW

Interprofessional practice in the ICU has been embraced as a standard of care since the early origins of the Society of Critical Care Medicine (SCCM) (1, 2). This focus has been instrumental in improving the care and outcomes of patients with life-threatening illness and injuries utilizing teams of critical care professionals (2). The ICU team is typically comprised of physicians, bedside nurses, nurse practitioners (NPs), physician assistants, clinical pharmacists, respiratory therapists (RTs), dieticians, physical/occupational therapists, case management and social work, dietician/nutritionists, spiritual support, as well as clinicians-in-training, among others. In the interprofessional team model, members of the ICU team communicate, collaborate, consult, and capitalize on the individual expertise of each team member (3). As highlighted by Dr. Max Harry Weil, the first president of SCCM, the ICU team is committed to bringing orderliness and expertise to the management of the critically ill patient (2). The coronavirus disease 2019 (COVID-19) pandemic and news reports of patients in the ICU during the pandemic served to raise the awareness of the general public of ICU care. More than ever, the importance of team-led care in the ICU became evident during the ongoing pandemic. In this article, part of a series on the 50th anniversary of SCCM in *Critical Care Medicine*, we review key aspects of interprofessional practice in critical care.

Efforts to advance interprofessional team-based care in the ICU are essential for improving patient outcomes and ICU team performance (4). Evidence-based best practice for effective interprofessional team care has identified the importance of multidisciplinary rounds that include ICU patients and family members in the care discussions and decision-making, and uses communication strategies that foster inclusive and supportive behaviors to enhance interprofessional collaboration in the ICU (5). A review by the American College of Critical Care Medicine (ACCM) Task Force on Models of Critical Care highlighted the importance of multidisciplinary ICU rounds in reducing mortality independent of the care team structure (1). Additionally, optimal interprofessional team performance also appears contingent upon open communication, conflict resolution, cooperation, coordination, and coaching between individual team members (**Table 1**) (6). The frequent changing of individual ICU team members due to rotations and different schedules from day to day has been identified as a potential challenge in ICU team performance (7, 8). However, ICU professionals function cohesively as a team, sharing their

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TABLE 1.
Key Qualities for Promoting Interprofessional Team-Based Care in the ICU

Effective communication
Mutual respect
Collaboration
Consultation
Cooperation
Cohesion
Adaptability
Coaching
Strategic decision-making
Defining expectations
Resolving challenges
Team identity
Psychologic safety

Stollings et al 2019 (5), Salas et al 2015 (6), and Durbin 2006 (3).

individual expertise and the perspectives of other team members day to day, as well as providing seamless continuity in patient care (9). Based on the COVID-19 pandemic, novel staffing models were developed to maximize critical care expertise to manage patient care needs and built new, nontraditional teams, with rapidly upskilled nurses and other staff (10, 11).

In caring for the most critically ill patients, ICU team members often work in physically, emotionally, and ethically challenging environments. This can lead to provider burnout and dissatisfaction, which can be avoided with good team performance (Table 1). In a recent study examining the quality of interprofessional collaboration involving 2,992 clinicians working in 68 adult ICUs in 12 European countries, ICU and clinician characteristics that were associated with lower clinician "intent to leave" were mutual respect, open interdisciplinary reflection, and a direct approach to difficult decision-making including end-of-life decisions (12).

INTENSIVIST-LED CARE IN THE ICU

Intensivists are physicians who have completed training in one of several primary specialties (i.e., internal medicine, anesthesiology, emergency medicine, surgery, neurology, and pediatrics) who have additional subspecialty training in critical care medicine (13). Over the past several decades, ICU care evolved from managing critically ill patients in open units where multiple physicians were admitting and directing patient care without the presence of intensivists to a closed model of care, where a dedicated team or teams provide care. Intensivist-led care in the ICU care is now advocated for the care of critically ill patients (1, 3), and SCCM outlines a number of key roles of the intensivist, including ICU team leadership, oversight of ICU care and decision-making, and coordination of care with specialists in management of the multiple health problems of ICU patients (**Table 2**) (14).

Intensivist staffing models vary somewhat to meet the around-the-clock care demands in the ICU, although 24 × 7 intensivist staffing has not been consistently associated with significant decreases in ICU mortality to justify the cost of nighttime intensivists when a high-intensity staffing models are employed (1, 15–17). In one recent meta-analysis, high-intensity intensivist staffing (mandatory consults or transfer of care to the intensivist-led ICU team) was associated with improved mortality when compared with low-intensity staffing (no mandatory intensivist involvement); however, the addition of nighttime intensivist coverage did not result in improved mortality over that produced by high-intensity daytime staffing alone (15). Similarly, in another study of 49 ICUs in 25 hospitals using the Acute Physiology and Chronic Health Evaluation database and a questionnaire to assess intensivist staffing, nighttime intensivist staffing again failed to show an effect on mortality in the units with high-intensity daytime intensivist staffing, although nighttime intensivist staffing did improve mortality in ICUs with low-intensity daytime staffing (16). This lead to the suggestion that 24 × 7 intensivist staffing models may not be an effective use of intensivist resources in units with high-intensity staffing models (16, 17). Interestingly, however, in another recent study, implementation of nighttime coverage with in-house nonintensivist ("nocturnist") physicians in a unit with a high-intensity staffing model did result in significant decreases in ICU length of stay (18). Independent of the coverage model employed to meet 24 × 7 demands in the ICU, intensivist-led multidisciplinary team models of ICU care are associated with decreased mortality risk for critically ill and injured patients (1, 19).

TABLE 2.
Interprofessional Team Member Roles in the ICU

Intensivists
Provide leadership and oversight of ICU care
Lead multidisciplinary rounds
Oversee the many decisions involved in a critically ill patient's care
Coordinate other services the patient may need–including those from specialists
Diagnose, manage, and deliver the care of critically ill patients
Have the medical training and skills to manage multiple health problems, including but not limited to:
Cardiovascular: shock, myocardial infarction, cardiac failure, and arrhythmias
Respiratory: prevention and treatment of pneumonia, respiratory failure, acute respiratory distress syndrome, chest trauma, smoke inhalation, and burns
Neurologic: stroke, traumatic brain injury, intracranial hypertension, seizures, and brain death evaluation
Renal: insufficiency or failure, electrolyte and acid base disorders, and rhabdomyolysis
Endocrine disorders: adrenal insufficiency, diabetic emergencies, and thyroid storm
Gastrointestinal: pancreatitis, gastrointestinal bleeding, and hepatic failure
Pharmacologic emergencies: overdose, drug reactions, and poison
Hematologic: anemia, coagulation disorders, and thrombotic disorders
Infectious disease: treatment of multiple infections and recognition of and treatment of sepsis
Nutritional: prevention, recognition, and treatment of malnutrition
Able to manage or perform certain unit-specific procedures, including but not limited to:
Endotracheal intubation and mechanical ventilation
Placement of intravascular catheters, including central venous catheters, pulmonary artery catheters, dialysis catheters, and arterial catheters
Cardiac pacing device insertion and management
Tube thoracostomy
Pharmacists
Assist healthcare team members in making informed decisions of pharmacotherapy options
Provide clinical pharmacotherapeutic consults to the care team
Review the medication history to determine which maintenance medication should be used
Prospectively evaluates all drug orders for appropriate indication, dose, interactions, allergies, and monitors for adverse drug events
Provide pertinent, comprehensive drug information
Collaborate with the healthcare team to prevent potentially inappropriate drug therapy
Provide pharmacokinetic monitoring and therapeutic adjustments with targeted drugs
Regularly attends rounds as member of a multidisciplinary critical care team
Assist with medication reconciliation at the time of ICU admission and discharge
Educate patients and caregivers on medications used in critical care
Perform independent patient assessments
Provide antimicrobial stewardship and monitoring services for anti-infective agents
Participate in resuscitation of emergencies with advanced life support skills
Provide drug therapy–related education
Review, consult, and advise on nutrition therapy

(*Continued*)

TABLE 2. (*Continued*)
Interprofessional Team Member Roles in the ICU

Respiratory therapists
Use protocols or guidelines based on evidence-based medicine and standards of practice targeted at improving patient outcomes
Implement respiratory therapy and diagnostic procedures as well as technology in the treatment and prevention of disease
Patient observation and monitoring of clinical signs, symptoms, and physiologic changes related to respiratory care and diagnostic interventions
Provide patient and family education to advance their knowledge of the disease process and understanding of prescribed therapy as well as resources available to assist them
Develop and facilitate disease management, patient care plans, and pulmonary rehabilitation
Participate in research to better understand current practice, improve patient outcomes, and advance the field of respiratory care
Promote cardiopulmonary wellness and prevention through public education
Facilitate training of the future healthcare professionals
Nurses
Provide direct care or influence care for acutely/critically ill patients who are at high risk for actual or potential life-threatening health problems
Monitor the critically ill patient including vital signs and physical assessment findings
Assess, plan, implement, and evaluate healthcare services for critically ill patients
Practice in settings where patients require complex assessment and therapies, high-intensity interventions, and high-level, continuous nursing vigilance
Lead and participate in collaborative interprofessional teams
Provide critical care treatments including oversight of mechanical ventilation, invasive monitoring, and other life support equipment
Respond to the unique needs of patients and families coping with unanticipated illness or injury and treatment, and advocate for their choices in quality-of-life and end-of-life decisions
Ensure the delivery of safe and high-quality patient care to critically ill patients
Collaborate with interprofessional team and provide oversight of patient care
Communicate and provide for family-centered care in the ICU
Clinical nurse specialists
Provide expert specialty consultation to nurses and other members of the ICU team related to complex patient care needs
Collaborate and consult with the interdisciplinary team, patient, and family
Coordinate patient/family education related to illness/disease, treatment plan, and medications (family-centered care)
Assess the nursing practice environment and processes for improvement opportunities
Incorporate national guidelines into ICU protocols and practice (e.g., Pain Agitation Delirium, Immobility, and Sleep Disruption and Nutritional Support Guidelines, Assess, Prevent, and Manage Pain, Both Spontaneous Awakening Trials (SAT) and Spontaneous Breathing Trials (SBT), Choice of analgesia and sedation, Delirium: Assess, Prevent, and Manage, Early mobility and Exercise, and Family engagement and empowerment Bundle, Surviving Sepsis Campaign, Healthy Work Environment Standards)
Mentor nurses and nursing staff in using evidence-based practice principles
Lead and participate in systematic quality improvement and safety initiatives based on precise problem/etiology identification, gap analysis, and process evaluation at the unit and system level
Interface with clinicians and leaders across the continuum, leading system-wide initiatives and using research and clinical expertise to guide implementation and adoption of best practices at the bedside

(*Continued*)

TABLE 2. (*Continued*)
Interprofessional Team Member Roles in the ICU

Competency development and education of nurses and other frontline staff
Consultation and research support of quality improvement and institutional review board activities
Nurse practitioner and physician assistants
Assist in the care management of critically ill patients
Prescribe and perform diagnostic, pharmacologic, and therapeutic interventions consistent with education, practice, and state regulations
Collaborate and consult with the interdisciplinary team, patient, and family
Patient and family education regarding anticipated plan of care
Lead, monitor, and reinforce practice guidelines for ICU patients (e.g., central line insertion procedures, infection prevention measures, and stress ulcer prophylaxis)
Promote and enhance communication with other ICU professionals: registered nurses, clinical nurse specialists, registered respiratory therapists, nutritional support team, and consulting services
Perform procedures (as credentialed and privileged, such as arterial line insertion, suturing, and chest tube insertion)
Transfer and referral consultations
Serve on rapid response and post-ICU discharge follow-up teams to coordinate care
Lead quality-assurance initiatives such as ventilator-associated pneumonia bundle, sepsis bundle, and rapid response team

References: SCCM (14), American Association of Critical Care Nurses (22), Kleinpell et al (30), Lat et al (60), and American Association of Respiratory Care (62).

HISTORY AND ROLES OF NURSES IN THE ICU

ICU nursing has evolved considerably since its early origins in the time of Florence Nightingale, when injured British soldiers in the Crimean War of the 1850s were segregated based on acuity to provide more intensive care by special-duty nurses (20, 21). During the latter 19th century, intensive nursing care of acute hospitalized patients was provided by locating the sickest patients closest to the nursing stations. With advancements in technology in the 20th century, including continuous monitoring and the development of life support devices such as ventilators and newborn incubators, intensive care nursing evolved rapidly (21). The American Association of Cardiovascular Nurses was founded in 1969 to help educate nurses in the care of critically ill patients, and shortly thereafter, in 1971, the organization became known as the American Association of Critical Care Nurses (AACN). According to the AACN definition, "the scope of critical care nursing is defined by the dynamic interaction of the critically ill patient, the critical care nurse, and the critical care environment" (22). ICU nursing is distinguished from general care nursing by the severity of patient illness, the skill set of the nurse, and the setting where care is provided (20). The roles and scope of practice for ICU nurses specifically involve providing direct and comprehensive care for acutely or critically ill patients including critical care treatments, oversight of life support equipment and invasive monitoring devices, support for patient- and family-centered care in the ICU, and overall assurance of the delivery of safe and high-quality patient care in collaboration with the interprofessional ICU team (Table 2).

By the late 1960s, the majority of U.S. hospitals with 500 or more beds had an ICU (20). Similar to the nurse-anesthetist and nurse-midwife programs that had provided specialty education and training for several decades, critical-care education programs in schools of nursing were also developed to support intensive care as a specialty area of nursing practice. Master's degree programs for clinical nurse specialists (CNSs) began in the late 1940s, and the first NP program was opened at the University of Colorado in 1965 (20). Soon thereafter, specialty-focused NP programs evolved and national certification for nurses working in acute and critical care—acute care NPs—began in 1995. More recently, certifications for acute care pediatric NPs and for CNSs working in the ICU have also became available.

The use of NPs in the ICU is now a well-established model for providing care for acute and critically ill patients, and the integration of NPs as part of the

medical team in acute, emergent, and intensive care has grown significantly in recent years. This was initially due in some large part to increased demands imposed by the aging population and increasing numbers of complex care patients coincident with work hour restrictions for physician trainees and, more recently, by increased availability of NPs, and continued demonstration of their contributions and value (23, 24). The important role of NPs as alternate providers in the management of critically ill patients has also been recognized and included in the LeapFrog Group ICU physician staffing guidelines (25), and a number of workforce documents have similarly identified NP integration into ICU care models as an important solution to meet qualified professional staffing needs in the ICU (15, 27). There are now nearly 250,000 NPs nationally, with more than 20,000 certified as adult or pediatric acute care providers (28). Twenty-eight percent of NPs work in hospital settings, with 5.8% working in emergency rooms or urgent care settings and 12% working in critical care (28).

Similarly, CNSs, who are also advanced practice nurses, play a significant role in the ICU through their roles in supporting patient care and nursing practice, and influencing organizational change through quality improvement initiatives, promoting evidence-based practice, staff nurse education and competency assessment, consultation, and research (Table 2).

Studies related to bedside clinical nursing care in the ICU have identified an association between nurse staffing and patient outcomes, with higher nurse-to-patient staffing ratios being associated with lower rates of infectious and postoperative complications, fewer unplanned extubations, and lower mortality (29). A growing number of studies have also demonstrated the positive impact of NPs and CNSs on outcomes in acute and critical care settings (30–33). Together these studies identify the value of advanced practice registered nurses in patient care management, continuity of care, improved safety and quality, increased patient, staff and family satisfaction, enhanced educational experiences of resident and fellow physician trainees, and decreased resource use and costs of care. Collectively, ICU nurses, NPs, and CNSs are essential members of the ICU interprofessional team who collaborate to provide patient care and management, promote implementation of evidence-based best practices, and ensure safety and continuity of care.

HISTORY AND ROLES OF PHYSICIAN ASSISTANTS IN THE ICU

The first Physician Assistant (PAs) training program was created at Duke University in the mid-1960s because of a perceived shortage of primary care physicians. Former military corpsmen were given advanced training using an abbreviated medical school curriculum based on general medical practice that was originally designed for WW II military physicians (34). The early PA graduates were typically placed in underserved rural healthcare settings as primary care providers. Now 50-plus years later, PAs can be found in virtually every medical specialty (35). With their general medical training and background and a master's degree, nationally certified PAs have adapted to specialty practice, including critical care, through orientation and on-the-job training with consulting physicians or experienced PAs who have practiced in the specialty. Commonly, the clinical time of PAs is divided with other responsibilities including assisting in surgery or seeing other patients in the clinic or on the hospital floors. In the ICU, an intensivist or other appropriate physicians are consulted for complex problems such as difficulty with ventilator management or weaning.

Several university programs have trained PAs in a number of "specialty" clinical areas including surgery (University of Alabama—Birmingham), pathology (Duke University), anesthesiology, and critical care (Emory University). Some of these programs did not persist over time (e.g., pathology), whereas others flourished and developed national certifying exams (e.g., anesthesiology). At several institutions (e.g., Emory University and Grady Hospital, Atlanta, GA), PAs were given critical care specialty training to practice in the ICU and were then used for ICU coverage, typically to support traditional coverage provided by physician trainees.

There was little mention of PAs contributions in the critical care literature until 1991 when Dubaybo et al (36) described their on-the-job training program and use of PAs in a medical ICU, and demonstrated equivalent outcomes when care was provided by the PAs versus physician trainees over a 4-year period. A subsequent letter in *Chest* (37) in early 1992 provided additional support for PA practice in the ICU and further delineated PA qualifications and clinical duties.

The publication of the Leapfrog Group ICU physician staffing guidelines in 2000, which acknowledged a role for PAs and NPs as "extenders" to help provide intensivist-led care in the ICU to decrease mortality and cost of care, resulted in a paradigm shift for ICU staffing. A considerable amount of literature that has subsequently appeared has further supported the evolving new roles of PAs and NPs as critical care providers in the ICU (30, 38). This has included recent reports in which PA authors and coauthors describe their specific clinical roles and duties in the ICU (Table 2) (30, 39, 40).

A recent survey by the National Commission on Certification of PAs indicates the number of active PAs in acute and critical care practice remains small (Emergency Medicine 13% and Critical Care 1.5%) (35). However, this relatively small PA contingent in critical care has demonstrated their commitment by their participation in activities and advancement in SCCM. In the early years, PAs interested in critical care often joined the Society using an alternate professional credential, and early SCCM meetings had only a few PA members in attendance. However, since establishment of the PA section of the Society in 1995, PA interest in critical care has increased and membership in the PA Section has grown to now more than 375 members over the past decade. As membership increased, so has participation and educational output from the PAs in the Section including collaboration with their NP colleagues in a number of webinars on topics of mutual clinical and administrative importance to the group and establishment of a vibrant networking community to provide mentorship and mutual support. The Section also awards travel grants to the annual SCCM Congress for PAs with research abstract presentations, and PAs and NPs are intimately involved in both editions of the SCCM monograph on the integration of PAs and NPs into critical care practice (41).

In recent years, PAs have contributed to leadership in SCCM, with PAs serving as members, chairs, and cochairs of SCCM committees including Billing and Coding, eResource, ACCM Credentials, Strategic Planning, and SCCM Congress Planning. Notably, 17 PAs have been inducted as Fellows in ACCM. In addition to their increasing role in critical care delivery and Society activities, PAs have assumed a number of important leadership positions within their individual healthcare entities, as well as in local and national healthcare organizations. PAs can now be found in roles of institutional Chief of Advanced Practice Providers (APPs) in critical care, codirectors for quality and safety, chair for the Council on Surgical and Perioperative Safety (American College of Surgeons), Directors of Critical Care Medicine APP Fellowships and Residencies, Associate Professors of Clinical Practice, and Chairs of regional SCCM societies. Overall, PAs in critical care medicine are growing in number and flourishing. The perceived need for advanced training has further given rise to the establishment of 11 clinical postgraduate training programs nationally providing 6–12 months of focused critical care training (42–43), and an accreditation process has recently been developed to assure quality for these new educational experiences (44). Notably, similar efforts to introduce PAs (and NPs) into critical care practice are ongoing in the United Kingdom (45) and the Netherlands (46).

HISTORY AND ROLES OF PHARMACISTS IN THE ICU

Although there are anecdotal reports of pharmacists working in direct patient care settings as early as the 1930s, the earliest publication of this practice dates back to the 1950s (47). The most widely cited origin of the clinical pharmacist (or what is now referred to as a clinical pharmacy specialist) is the "ninth-floor project" that began in 1966 at the University of California San Francisco (UCSF) College of Pharmacy and HC Moffitt Hospital. This Pharmaceutical Services Project, the brainchild of Chief Pharmacist Eric Owayng, was initially started as a surgical pharmacy satellite, with the primary function of dispensing drugs. Under the leadership of UCSF faculty Richard de Leon, PharmD; Don Holsten, PharmD; and others, this pilot evolved to become an integral part of daily surgical rounds, providing pharmacy recommendations regarding medication management as well as pharmacy monitoring for adverse drug-related events. The pharmacist's role soon expanded to include attendance and support during "Code Blue" emergencies and development of a drug box for these codes. Participation in total parental nutrition recommendations followed, and 12 months later, students were introduced to the ninth-floor project for training, in what was now called the "clinical pharmacy" (48, 49).

Over the next 10–15 years, momentum developed to advance the nascent clinical pharmacy movement in colleges and schools of pharmacy and health systems across the nation, and there were a number of other demonstration projects. Although specific published descriptions of clinical pharmacy services and the critical care pharmacy specialist were lacking, a number of published papers highlighted the importance of drug dosing in critically ill patients. One landmark article published in 1976 described the "Sawchuck and Zaske" method for dosing gentamicin in burn patients (50). This provided an opportunity for clinical pharmacists to introduce and begin discussions of pharmacokinetics, using terms such as relative volume of distribution, elimination rate constant, and peak and trough concentration, with their physician and nurse colleagues. What was arguably the most significant impact of this article was the resulting rapid expansion of clinical pharmacy services to include a pharmacokinetic dosing service for dosing recommendations of aminoglycosides and other narrow therapeutic spectrum drugs based on sound pharmacokinetic data. This became the natural domain of the pharmacist in the ICU, and the unique skill of the pharmacists to accurately predict and adjust drug dosing using mathematical equations gave them professional stature and a real purpose in the support they provided to other health professionals at the bedside in the ICU.

One of the first documented publications on implementation of critical care pharmacy services was found in The Practice of Pharmacy textbook authored by Angaran (51) in 1981. In the chapter on ICU care, there was both a thorough description of critical care pharmacists at the time and an algorithm for pharmacy services implementation in the ICU. In the document, there were also recommendations for training critical care pharmacists. Angaran (51) advocated not only for a strong background in drug therapeutics but recommended that critical care pharmacists also be well-versed in several of the proposed competencies for critical care physician training including emergency medical care, cardiopulmonary resuscitation, anesthesia techniques, respiratory care, arrhythmia control, cardiovascular physiology, temperature control, infection control, and management of organ failure. These recommendations have subsequently served as the pillars of critical care pharmacy training.

During the 1980s and 1990s, the specialty of critical care pharmacy grew as did the integral role of the pharmacist as a member of the ICU multidisciplinary team (52–54). Evolution of this role in the ICU has continued to now include involvement in medical, surgical, cardiovascular, neuro, and burn critical care. In 1990, a milestone was marked with the publication of the first standard for residency training in critical care pharmacy that was approved by the American Society of Health System Pharmacists (ASHP) (55). Concurrent with the publication of these residency standards, the SCCM approved a Clinical Pharmacy and Pharmacology Section. Together with the other pharmacy organizations (ASHP and American College of Clinical Pharmacy [ACCP]), this has led to the development of strong and vibrant critical care pharmacists interest groups. In 1995, Debi Armstrong, PharmD, was the first pharmacist elected to SCCM Council as an at-large candidate, and a specific pharmacy seat on Council was subsequently designated in 1999. An SCCM milestone for pharmacists was reached in 2010 with the election of Judi Jacobi, PharmD, as the President of SCCM. That was followed by the election of Keith Olsen, PharmD, as a Chancellor for the ACCM in 2018, another pharmacist first.

The development and success of critical care pharmacy practice has been highlighted in a number of publications over the past 30 years (52–57). Perhaps the most influential was the *Journal of the American Medical Association* publication of the study by Leape et al (58) in 1999 demonstrating the positive impact of pharmacists in reducing preventable adverse events in a major academic medical center ICU. In the years following that article, ICU pharmacy services have expanded rapidly, and the number of residency training programs has increased. In 2013, critical care pharmacists petitioned the Board of Pharmacy Specialties for a critical care board examination that was subsequently approved and first offered in 2015 (47). Today, there are over 2,500 pharmacists worldwide with the designation Board Certified Critical Care Pharmacist. Notably, board certification has subsequently been adopted by the ACCM for 2021 as a standard for pharmacists to be considered for fellowship in the College.

Several other important position papers have been published that have defined standards for critical care pharmacy practice and services, as well as the training requirements. The Position Paper on Critical Care

Pharmacy Service 2000 was one of the most influentials in organizing all the available information related to critical care clinical pharmacy services (59), and this article continues to serve as an essential tool to benchmark and define the domains of pharmacy activities and ICU pharmacy services. A joint task force with SCCM/ACCP/ASHP has recently produced an updated position paper to account for the significant changes in healthcare and critical care. In this article, 44 original recommendations were updated, and 38 new recommendations were introduced, the majority of which related to defining optimal critical care pharmacist duties and pharmacy services (60). Table 2 provides a summary of the recommended activities for pharmacists in the ICU. The rate of change for critical care pharmacy continues on a rapid pace since the UCSF ninth-floor project. As technology changes healthcare, the role of the pharmacist will also continue to evolve and adapt to meet the needs and challenges associated with caring for critically ill patients.

HISTORY AND ROLES OF RESPIRATORY THERAPISTS IN THE ICU

Beginning with "oxygen technicians" who administered oxygen therapy and inhaled aerosols in the 1940s and the "inhalation therapists" in the 1950s who also provided intermittent positive-pressure ventilation and aerosolized medication treatments, the role of respiratory healthcare professionals has evolved considerably. With introduction of mechanical ventilators, blood gas analysis, and pulmonary function testing, formal training programs for these respiratory therapy professionals were established in the 1960s, and the designation of RT became the standard in 1974 (61). That same year, the first professional organization for RTs, the Inhalation Therapy Association was founded in Chicago, IL.

By 1982, this organization had evolved to become the American Association of Respiratory Care (AARC) (61), and there are now 50 state respiratory care associations that are chartered affiliates of the AARC. The AARC provides clinical practice guidelines, continuing education, networking through its sections, leadership opportunities, and advocacy at both the state and federal levels. The organization also supports the journal *Respiratory Care*. The AARC published a position paper defining Respiratory Care Scope of Practice and provides that: "Respiratory Therapists are health care professionals responsible for the care of patients with deficiencies and abnormalities of the cardiopulmonary system. The scope of practice crosses all patient, client, and resident populations and care sites including, but not limited to various inpatient and outpatient settings (e.g., acute care, urgent care, long-term care, subacute care, and skilled nursing facilities), physician's offices, sleep labs and clinics, vendor and industry venues, and the patient's home." (62) Table 2 provides additional details regarding the RT practice, which is also governed by state licensure laws.

RT licensure in 49 states is based on credentialing by the National Board of Respiratory Care (NBRC; https://www.nbrc.org/). A Certified Respiratory Therapist (CRT) represents the entry-level credential for the profession that is obtained by passing the Therapist Multiple Choice (TMC) examination. A Registered Respiratory Therapist (RRT) represents an advanced credential earned with a higher cut score on the TMC, as well as a passing performance on a clinical simulation examination (CSE). The CSE requires the examinee to gather appropriate clinical information through physical examination and testing, and then use that information to make appropriate clinical decisions. Most states allow practice with the CRT designation alone although several states have recently moved to begin requiring the RRT credential to practice. Once a therapist earns the RRT, they can take specialty examinations to earn additional credentials as a neonatal-pediatric (RRT-NPS) and/or adult critical care specialist. These specialty credentials signify the enhanced critical skills necessary for RTs who work in the critical care environment. The NBRC also offers credentialing related to pulmonary function testing (certified pulmonary function technologist or registered pulmonary function technologist) and sleep disorder specialty (SDS) (certified respiratory therapist-SDS or registered respiratory therapist-SDS).

To gain access to the credentialing examinations, an individual must graduate from a respiratory care education program accredited by the Commission on Accreditation for Respiratory Care (https://www.coarc.com/). As of December 31, 2019, there were 420 programs accredited of which 82% award an associate degree, 17% award a baccalaureate degree, and 1% (five programs) award a master's degree (63). In 2018, the reported number of graduates from all programs

was 6,219, which represented a 13.8% decrease from 2012. Since the demand for RTs is expected to continue to grow by 21% from 2018 to 2028 (64), the decline in enrollment presents a challenge to meet future workforce demands. This will need to be addressed by professional organizations using outreach to educate the public regarding the opportunities in respiratory care and recruitment efforts for potential qualified applicants.

In 2018, there were 134,000 RTs with 81% of these therapists working in hospital settings (65). A majority of RTs in the acute care setting work in ICUs where they are responsible for the technical aspects of the various bedside clinician-ordered respiratory therapies including oxygen, airway clearance, lung expansion, intubation, blood gas measurement, pulmonary function testing, and bronchoalveolar lavage. In addition, RTs may also have independent professional practice roles as physician extenders in the application of protocols that permit the therapist to allocate respiratory care therapies including oxygen and medicated aerosols as needed to avoid complications, reduce misallocated therapies, and improve patient outcomes (61). RTs may also make protocol-driven ventilator setting changes as needed, and protocol-driven weaning from mechanical ventilation has become a recognized standard of practice since the early 2000s (66). A number of studies have demonstrated that protocol-driven weaning involving RTs results in significantly shorter durations of mechanical ventilation. This approach resulted in an estimated cost savings of $42,960 per patient in one recent study when compared with standard physician-driven weaning (65). Similarly, an RT-implemented lung-protective ventilation strategy in recent studies demonstrated an increase in the use of this strategy, and increases in ventilator free days and survival in both acute respiratory distress syndrome (ARDS) (67) and non-ARDS (68) patients.

In addition to ventilator management, RTs have also repeatedly demonstrated their value in improving outcomes using "assess and treat" protocols. A quality-improvement project in surgery patients receiving an RT-driven assess and treat protocol demonstrated shorter ICU and hospital stays, and lower hospital costs compared with preprotocol physician-directed respiratory care (69). The addition of RT involvement in an automated rapid response team has also recently been shown to result in lower hospital mortality and length of stay, and a decrease in the number of subsequent cardiopulmonary arrests (70).

The role of the RTs has grown and evolved considerably since the early days as oxygen technicians in the 1940s to important members of the multiprofessional ICU team to help coordinated comprehensive respiratory care including support for respiratory failure and weaning from mechanical ventilation. The ability of the RTs to develop appropriate respiratory care plans that target therapies to prevent pulmonary complications will continue to contribute to optimal patient outcomes including shorter times on mechanical ventilation and shorter ICU length of stay. Technological advances that alert clinicians and RTs of potential problems at earlier time points will enhance RTs ability to intervene in a timely manner to help prevent complications and improve outcomes.

BUILDING THE BUSINESS CASE FOR INTERPROFESSIONAL TEAMS IN THE ICU

SCCM and the American College (ACCM) endorsement of intensivist-led multidisciplinary team care in the ICU is based on considerable experiential and published evidence demonstrating critical care–trained physicians, nurses, NPs, PAs, pharmacists, RTs, and other providers, working as a team in their respective and evolving roles in the ICU, provide optimal outcomes and value for critically ill and injured patients (1, 3, 9). Many of the important contributions of these professionals are highlighted in this review, as are the important team functions for delivery of well-coordinated care in the ICU (Table 1).

Making a "business case" for these multidisciplinary professionals in the ICU may thus seem unnecessary, perhaps even inappropriate given the overwhelming evidence (71). However, critical care is a major contributor to the cost of inhospital medical care, and many hospitals and provider groups operate on small margins that leave little room for inefficiency or waste (72, 73). There has thus been understandable scrutiny of the various models to meet the around-the-clock demands in the ICU, with costs for the multidisciplinary professionals being significant barriers to ICU staffing to meet SCCM/ACCM and Leapfrog standards despite their well-demonstrated value (1, 25). The simple adage, "we cannot provide care that we cannot pay

for," stands as an important reminder. Consequently, critical care and hospital leaders, working with their business professionals, are challenged to develop and communicate a business case to the key stakeholders and sponsors that allow for high-quality patient care in their ICUs, which is efficient and cost-effective, and which supports both the team professionals and the financial stability of the enterprise.

In considering the business case for multiprofessionals in the ICU, clinical and financial data are essential to benchmark and follow performance, and to provide the accounting needed to "connect the dots" between team structure and function, and impact on quality and cost. Data infrastructure to "measure what matter most' is highlighted by the National Academy of Medicine as an essential need to align goals in healthcare and "achieve better health at lower cost" (73). Medication costs account for more than half of the variable costs in the ICU (74), and studies demonstrating that critical care pharmacist can result in fewer complications related to medication errors, with resulting decreases in mortality and length of stay, as well as improved drug utilization leading to decreases in overall costs of care, provides an important example of the connect-the-dots exercise (56, 58, 76, 77). Lilly et al (78, 79) linked processes of early intensivist review of care plans, assurance of best practice adherence, and more timely responses to immediate care needs using an ICU telemedicine approach, to significant reductions in mortality and lengths of stay, and overall reductions in cost of care. Similar examples have been provided for each of the ICU team professional groups in this review, including processes shown to improve outcomes and lower costs. These should collectively be considered in the business case and used to guide measurement of "what matters most" so as to capture impacts (72, 74, 76, 78). Such data are also valuable to provide performance feedback and recognize ICU team professionals to support desired team behaviors, help with change management, and promote goal-directed performance improvements. Providing evidence of quality and value supports and acknowledges the contributions of the ICU team professionals, engenders open communication and engagement within the team, and leads to sustainable team processes that take care of patients and their families, as well as the professionals and caregivers in the ICU (3, 4, 6).

When developing or iterating a multidisciplinary team model and business case to meet care needs, it is recognized that financial concerns are not primary drivers (1, 74). However, models must be cost-effective and should not unnecessarily waste precious human resources using a one-size-fits-all approach. Primary consideration should be given to providing access to critical care resources to meet the needs of the population being served, ideally taking advantage of other available resources in the region and beyond. Multidisciplinary team models need to be right-sized to be efficient, while also cost-effective (74). Intensivist-led multidisciplinary teams, higher nurse-to-patient ratios, expanded coverage with APPs, and dedicated ICU pharmacists have all been linked to improvement in clinical outcomes and are thus desirable if available and affordable (1–3). However, these may not be practical options in all ICUs (80). Additionally, it should also be recognized that linkages between team members and the processes that lead to optimal outcomes are not clear (4). The finding that nighttime intensivist coverage used in many larger centers does not result in improvements in mortality or lengths of stay, as reported in both single prospective and multicenter retrospective analyses, is now incorporated in the recent SCCM/ACCM recommendation (1, 15–17). However, this recommendation is conditional on having a high-intensity daytime intensivist model of care (i.e., mandatory daytime consults or transfers of care to the ICU team) (1, 15–17) and is thus only relevant when evaluating the business case for that specific structural team component (nighttime intensivist) in that context (high-intensity daytime intensivist staffing). It may not be very helpful when trying to address the critical care needs for many smaller or rural hospitals, who may have little ability to recruit or efficiently use bedside intensivists (80). Furthermore, the finding that high-intensity daytime intensivist staffing obviates the need for an additional nighttime intensivist does not address the essential processes needed to provide the around-the-clock access to critical care support as recommended by the Leapfrog group (25), nor the expense. Indeed, the positive impact of the daytime intensivist would likely be hard to maintain if alternate providers and processes for essential off-hours access and support are not in place.

In this regard, when on-site intensivists are not available, a variety of multidisciplinary team structures

have evolved, including coverage using non-intensivist physicians or APPs and access to remote ICU telemedicine support (80). Certainly, there is ample evidence that APP providers provide high-quality and cost-effective critical care (30), and critical care–trained and ICU-dedicated APPs have the advantages of greater familiarity with critical care processes and protocols, and may also provide greater team stability compared with rotating nonintensivist physicians (30). APPs can also add considerable value in the business case related to their ability to bill and receive reimbursement from payers for professional services, similar to physicians, which can be used to offset costs (81). Multiprofessional team rounding and review of care plans has also been identified as a key team process that should be included in developing team models and the business case. This activity not only contributes to improvements in outcomes (3, 9) but appears to mediate in some large part the observed effects otherwise attributed to intensivist staffing (82). As pointed out in one recent analysis of ICU team behaviors and performance, group exchanges of information and decision-making on rounds are important for coordination of care that likely mediates team-related outcome improvements, and team rounds represent the singular activity in which the team professionals clearly function as a team (4). The low temporal stability of team members due to rotating schedules and the high rates of turnover and "burnout" do present challenges to maintaining healthy team dynamics and may detract from team function and effectiveness (4, 19). It is also clear that all teams are not created equally (6). It is thus important that lessons from the field of "team science" be used to better understand the linkage between team dynamics and performance in the ICU, and the relationship between team-related outcomes and patient-centered outcomes and costs (4, 6). Despite the variability in the specifics of the ICU team structure and processes employed to meet the around-the-clock demands in the ICU, the importance of cooperation among the dedicated multiprofessionals in the ICU clearly emerges as the most important factor in the delivery of optimal outcomes at the lowest cost (4, 6).

In closing, the "business case" for the physicians, nurses, APPs, pharmacists, RTs and other professionals in the ICU is clearly evidence-based. Multidisciplinary team models that comport with SCCM/ACCM and Leapfrog ICU staffing guidelines have been shown to deliver optimal outcomes for critically ill patients at lower costs. As described above, creativity and innovation over the last 50 years have led to a variety of processes by team professionals that have demonstrated value, improving both clinical and financial outcomes. Emphasis on the processes that lead to improved outcomes as well as team processes including multidisciplinary daily rounding is essential in the business case. Emphasis on continuous data collection related to quality and cost in the ICU is also essential to allow for continuous process improvement and to ensure financial stability for the enterprise. In this regard, care models need to be right-sized to meet needs, ensuring both access to around-the-clock critical care decision support and implementation of processes linked to optimal patient outcomes. Considerable recent data suggest ICU telemedicine approaches can help leverage limited resources and provide a cost-effective option to meet critical care access and process goals (78–80). This option may be particularly well-suited for smaller nonurban and rural hospitals that have difficulty justifying or maintaining on-site intensivist models (80). In a recent Center for Medicare and Medicaid Services project, development of a tele-intensivist-led care model, in concert with critical care training and deployment of beside APPs in the covered ICUs, resulted in high-quality care at a much lower cost compared with prior use of more traditional models (82).

THE NEXT 50 YEARS

The future for interprofessional team care in the ICU appears secure, as is the certainty that the roles and responsibilities of the team professionals will continue to evolve to meet the changing landscape in medicine and critical care, as they have over the last 50 years. The aging of the population will continue to challenge ICU team professionals to meet the demands with available resources. Innovation and process improvement, including increased use of evidence-based protocols and standardized care bundles will certainly continue, as will increased public scrutiny and demand for transparency and accountability. A number of emerging technologies will undoubtedly impact clinical practice in the ICU and the organizational structure of our multidisciplinary teams including the manners in which team professionals interact with other professionals and patients. Increases in available data and computing power will lead to more sophisticated alerting and artificial intelligence-assisted

decision support using machine learning. "Big data" approaches that integrate genomic and other complex datasets in decision-making will ultimately deliver truly personalized medicine in the ICU and beyond. This is clearly on the near horizon, as evidenced by focus on this topic at the recent SCCM Critical Care Congress. ICU telemedicine technology will also undoubtedly continue to advance as an approach to provide critical care access and support, driven both by the lasting influences of the current COVID-19 crisis, as well as the practicality and scalability, and potential reach of this technology and approach. Advances in virtual reality will further allow for enhanced remote presence, and enhancements in remote monitoring and alerting employing wearable and wireless devices, including wireless infusion pumps and servo devices, will allow for "smart" approaches for patient assessments and care delivery where and when it is needed. Importantly, promoting resilience and prevention of burnout in ICU providers remain paramount to ensuring clinician well-being, as has been highlighted in ongoing work of SCCM in conjunction with the Critical Care Societies Collaborative (83).

Efforts to "democratize" healthcare both nationally and globally will further push the boundaries in critical care to ensure critically ill or injured patients everywhere have access to "right care, right now." Therapeutic advances to support and mitigate organ failures, with advances in invasive and noninvasive approaches, new pharmaceuticals, and artificial organs, will continue at an accelerated pace to improve survival and quality of life, and these will have a major impact on critical care practice. Efforts to enhance end-of-life care and death with dignity by engagement with professionals in the social sciences, and palliative, hospice and pastoral care will help ensure that precious crucial care resources are used effectively and appropriately. This review provides a history of how critical care professionals have evolved to meet the changing landscape and challenges in healthcare for their patients over the last 50 years following the origin of SCCM. The COVID-19 crisis required that ICU teams stretch to meet unprecedented patient demand and work synergistically with flexible models of care. Attention to moral distress of ICU clinicians is paramount, and future challenges involving natural and other disasters will require investment to expand the workforce to meet future needs. During the pandemic, we have had the opportunity, as well as the obligation, to adapt, to innovate, and to meet the ever-changing needs for critical care medicine (11).

The next 50 years promise to be equally challenging and exciting as the last, and are certain to be met by the critical care professionals with equal passion and creativity. With the last 50 years as evidence, they are all certainly up to the challenge.

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