Adult Pulmonary Intensive and Intermediate Care Units: The Italian Thoracic Society (ITS-AIPO) Position Paper

Teresa Renda^a Raffaele Scala^b Antonio Corrado^c Nicolino Ambrosino^d
Adriano Vaghi^e on behalf of the Scientific Group on Respiratory Intensive
Care of the Italian Thoracic Society (ITS-AIPO)

^aCardio-Thoracic and Vascular Department, Respiratory and Critical Care Unit, Careggi University Hospital, Florence, Italy; ^bCardio-Neuro-Thoracic and Metabolic Department, Pulmonology and Respiratory Intensive Care Unit, Arezzo, Italy; ^cPneumology Centre, Sesto Fiorentino, Florence, Italy; ^dRespiratory Rehabilitation Unit of the Institute of Montescano, Istituti Clinici Scientifici Maugeri IRCCS, Pavia, Italy; ^ePresident of Italian Thoracic Society, Italian Association of Hospital Pulmonologists (ITS-AIPO), Milan, Italy

Keywords

Respiratory care units · Pulmonologist · Intensive care units · Acute respiratory failure · Cost-effectiveness

Abstract

The imbalance between the prevalence of patients with acute respiratory failure (ARF) and acute-on-chronic respiratory failure and the number of intensive care unit (ICU) beds requires new solutions. The increasing use of non-invasive respiratory tools to support patients at earlier stages of ARF and the increased expertise of non-ICU clinicians in other types of supportive care have led to the development of adult pulmonary intensive care units (PICUs) and pulmonary intermediate care units (PIMCUs). As in other European countries, Italian PICUs and PIMCUs provide an intermediate level of care as the setting designed for managing ARF patients without severe non-pulmonary dysfunction. The PICUs and PIMCUs may also act as step-down units for weaning patients from prolonged mechanical ventilation and for discharging patients still requiring ventilatory support at

home. These units may play an important role in the on-going coronavirus disease 2019 pandemic. This position paper promoted by the Italian Thoracic Society (ITS-AIPO) describes the models, facilities, staff, equipment, and operating methods of PICUs and PIMCUs.

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Introduction

Acute respiratory failure (ARF) represents one of the most important causes of intensive care unit (ICU) admission and readmission [1–3]. The limited availability of ICU beds represents a global problem, worsened during the current global outbreak of the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) [4].

Even though with considerable geographic variability, a recent study [5] has shown that the mean availability of ICU beds in Europe is 11.5/100,000 inhabitants; this ratio is far lower than that reported in the USA, which is 34.0/100,000 inhabitants [6]. In Italy, due to a reduced al-

location of healthcare resources [7], the number of critical care beds dropped from 12.5 in 2011 [5] to 7.8/100,000 inhabitants in 2017 [8]. Between 2010 and 2017, there was a 16% reduction in the number of beds in Pulmonology Units [8]. Consistently, the imbalance between the increasing prevalence of critical patients with ARF and the shortage of high daily cost ICU beds has stimulated new health cost-effective solutions.

Pulmonary intensive care units (PICUs) and pulmonary intermediate care units (PIMCUs) provide a specialized environment for the management of patients with severe ARF requiring an “intermediate” level of care between the ICU and the ward, to avoid the dangerous “underassistance” in the latter and the unnecessary “overassistance” in the former. This is helpful to keep a larger number of ICU beds free for sicker patients needing multiple organ support. Their activity may include preferentially but not exclusively non-invasive ventilation (NIV) treatment of ARF, weaning patients from invasive ventilation, tracheostomy care, and decannulation and discharge planning for ventilator-dependent patients [9–11]. The complexity of the interventions performed in PICUs and PIMCUs has increased significantly over the last 15 years, moving from widespread use of NIV to the application of ultrafiltration methods, extracorporeal carbon dioxide removal (ECCO₂R), high-flow oxygen therapy (HFOT), and analgo-sedation interventional procedures [12–17].

Two national surveys promoted by the Italian Thoracic Society (ITS) have shown a steady increase in the number of these units in Italy [18, 19]. Unfortunately, the last ITS census of all respiratory units reports that the number of beds for critically ill respiratory patients is underrepresented as compared to the estimated requirement (0.8 vs. 1–2/100,000 inhabitants) [10, 20]; moreover, PICU and PIMCU beds were found to be distributed heterogeneously across the country [19, 20].

The recent coronavirus disease 2019 (COVID-19) outbreak has demonstrated that the quick saturation of ICU beds with intubated patients could have been largely prevented if a stronger pulmonology network had been set up earlier to manage severe hypoxaemic patients with non-invasive respiratory techniques [21, 22]. Surprisingly, despite the strong rationale for the development of PICUs and PIMCUs, there are few recommendations and limited information about intermediate care facilities; moreover, these units are referred to in the literature under different names, such as “intermediate care units,” “highly dependent units,” “step-down units,” and “semi-intensive care units,” and this has created confusion in the identification of their role in healthcare systems.

Fig. 1. Consort flow diagram of the review process. The diagram illustrates the flow of identified records leading to the final inclusion of publications reported in the manuscript.

This position paper represents an update of previous recommendations of the Italian Thoracic Society (ITS-AIPO) and provides the minimum organizational standards for planning adult PICUs and PIMCUs [10, 11, 23]. The purpose of these recommendations is to promote better management of ARF and use of the resources available in health care.

Methods

Composition of the Study Group and Preparation of the Manuscript

The panel members (T.R., R.S., and A.C.) were selected by the ITS for their interest and expertise in respiratory critical care medicine. The expert panel was provided with background articles that reviewed the existing European and Italian documents on this topic [9–11] and the relevant articles obtained from a literature search. The panel produced a preliminary document, which was then subjected to external review (N.A.) for the final agreement. Consensus on the final document was achieved through a video conference, dealing with the following issues: (1) definition and level of care, (2) severity of respiratory failure, (3) economic and human resources, and (4) experienced staff and training.

The literature search was conducted through the PubMed National Library, Embase, and Google Scholar Beta databases, using the following keywords: “acute respiratory failure, ICU, respiratory care units, levels of care, Pulmonologist, mechanical ventilation, non-invasive ventilation, and cost-effectiveness” and specific keywords for each chapter of the document. Only publications in Italian and English were considered. Content experts were asked to indicate and add any studies, and a total of 160 articles were acquired. Those considered most appropriate and relevant for the update of the document were selected (Fig. 1).

Definitions and Levels of Care

The definition of PICUs and PIMCUs was expanded in view of the broader spectrum of related diseases and the recent techno-

Table 1. Definition of the levels of care and proposed classification of PICUs and PIMCUs

	PICU	PIMCU
<i>Major criteria</i>		
Nurse/patient ratio per work shift	>1:3	1:3 or 1:4
Bed equipment	Multi-function monitors* Intensive care and NIV ventilators	Multi-function monitors* Mechanical ventilators (for NIV, with intensive care ventilators available)
Treatment	Respiratory failure with or without other organ failures [§]	Respiratory failure (single organ failure)
Attending physician (working pattern)	24 h (dedicated)	On shift (not dedicated)
Mechanical ventilation	Invasive, NIV	NIV, invasive if necessary (only in tracheostomized patients)
Bronchoscopy	Inside the unit	Inside the unit
ABGA	Inside the unit	Inside the unit
Ultrasound	Inside the unit	Inside or outside the unit
HFOT	Inside the unit	Inside the unit
Education and training	Ad hoc and periodic educational programs for staff Training of residents and fellows	Ad hoc educational programs for staff Training of residents and fellows
Responsiveness to regional and national intensive care provisions	Responsive in event of disaster and pandemic Disaster and pandemic preparedness plan and capacity	Available in event of disaster and pandemic Resource for critically ill patients
Doctor	The responsibility must be assigned to an expert pulmonologist in mechanical ventilation	
<i>Additional criteria</i>		
ECCO ₂ R	Inside the unit	
Ultrafiltration device	Preferably inside the unit	
Research and quality program	Active contribution to clinical research Formal quality improvement program	Active collaboration to ad hoc clinical research Basic quality improvement program

Although the criteria listed may vary depending on regional resources, capabilities, and various changeable clinical needs, all the main criteria must be satisfied to define a unit at each level. PICU, pulmonary intensive care unit; PIMCU, pulmonary intermediate care unit; NIV, non-invasive ventilation; ECCO₂R, extracorporeal CO₂ removal; ABGA, arterial blood gas analyser; HFOT, high-flow oxygen therapy. * Multi-function monitors: oximetry, electrocardiogram, non-invasive blood pressure, and respiratory rate. [§] See Table 3 for clinical conditions requiring treatment in a general ICU.

logical enhancements of non-ventilatory support for critically ill respiratory patients [9, 11]. The PICUs and PIMCUs are defined as “a pulmonary monitoring and treatment area for patients with acute respiratory failure and with acute-on-chronic respiratory failure in whom non-invasive monitoring and respiratory support (NRS) (e.g., NIV and HFOT) techniques are mainly used. Difficult to wean tracheostomized patients are also admitted from general ICUs. The discharge planning of ventilator-dependent patients is part of the activities. Interventional procedures, such as bronchoscopy and pleural drainage, chest ultrasound, and analgosedation, are usually performed in these units to facilitate the management of ventilated patients.” An ERS Task Force and ITS documents identified 3 different levels of care among PICUs and PIMCUs (respiratory intensive care unit, respiratory intermediate care unit, and respiratory monitoring unit [MU]), stratified according to human and instrumental resources as well as the intensity of care [9, 11]. The authors approved the revised document, which main-

tained the 2 higher levels of care: PICUs and PIMCUs [9, 11], but not MU.

The former definition of MU did not fit the revised PICU and PIMCU criteria for several reasons: (1) this setting is much more similar to a ward than to an intermediate care unit in terms of intensity and complexity of intervention; for example, NIV and HFOT may be safely provided also in a respiratory ward to treat selected patients with less severe ARF by an expert team [24–26]; (2) the term is misleading as the activity of PICUs and PIMCUs is not limited to a simple “monitoring” activity but provides “active” respiratory support; and (3) currently, in Italy, there are 2 levels of care for critically ill patients defined as intensive and intermediate care units according to the types and complexity of the interventions available. For these reasons, the panel agreed to consider 2 levels of units based on (1) the nurse/patient ratio, (2) interventions performed to update the instruments, and (3) admission criteria (Table 1).

Table 2. Patients requiring treatment in adult PICUs and PIMCUs

COPD with ARF requiring mechanical ventilation, mainly non-invasive, and/or monitoring of vital parameters for ARF
Chronic restrictive diseases (neuromuscular and chest wall diseases and diffuse infiltrative lung disease) with ARF requiring mechanical ventilation, mainly non-invasive, and/or monitoring of vital parameters
Patients with central hypoventilation or sleep apnoea syndrome requiring hospitalization for ARF
Patients undergoing mechanical ventilation in an ICU, to complete weaning from the ventilator and/or to restore functional recovery before discharge to the hospital ward or home
Weaned tracheostomized patients to attempt decannulation
Patients requiring mechanical ventilation, mainly non-invasive, and/or monitoring of vital parameters due to respiratory complications after surgery
Patients requiring mechanical ventilation and/or monitoring of vital parameters for hypoxaemic ARF following pulmonary parenchyma diseases, with PaO ₂ /FiO ₂ ratio <300 and >100
Patients requiring mechanical ventilation and/or monitoring of vital parameters for acute asthma exacerbation
Patients needing interventional procedures (e.g., bronchoscopy, digestive endoscopy, PEG positioning, and trans-oesophageal echocardiography) with ARF during conventional oxygen therapy, HFOT, or NIV
PICU, pulmonary intensive care unit; PIMCU, pulmonary intermediate care unit; ARF, acute respiratory failure; COPD, chronic obstructive pulmonary disease; HFOT, high-flow oxygen therapy; NIV, non-invasive ventilation; PaO ₂ /FiO ₂ , partial oxygen pressure/fraction of inspired O ₂ ; PEG, percutaneous endoscopic gastrostomy.

Table 3. Clinical conditions requiring treatment in an ICU

Severe hypoxaemic ARF (severe ARDS) with PaO ₂ /FiO ₂ ratio <100 during invasive ventilation applicable in rescue treatments such as ECMO, nitric oxide, and pronation
ARF with multiple organ dysfunction syndrome requiring multiple organ support
ARF in patients with severe cardiac haemodynamic/electrical instability, for example, uncontrolled cardiac arrhythmia and/or systolic hypotension <70 mm Hg despite volaemic filling and/or use of vasoactive amines
Septic shock with ARF (only for PICUs not equipped to perform haemodynamic monitoring)
ARDS, acute respiratory distress syndrome; ARF, acute respiratory failure; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit; PICUs, pulmonary intensive care units.

The first level corresponding to the PIMCU was characterized by a nurse/patient ratio of at least 1:4, the routine use of non-invasive monitoring, NRS, and the application of invasive mechanical ventilation when necessary. The second level corresponding to the PICU was characterized by a nurse/patient ratio >1:3, with the possibility of managing ARF of any level of severity with invasive ventilation and NIV but not ARF with multiple organ failure requiring multiple organ support, cardiogenic shock requiring aortic counterpulsation, and severe refractory hypoxaemia requiring extracorporeal membrane oxygenation treatment. These conditions necessarily require treatment in general ICUs. Additional criteria were introduced regarding renal ultrafiltration and interventional lung assist for ECCO₂R. In recent years, reports from some PICUs have shown their capability to support patients presenting with

both ARF and acute renal failure by means of ventilation and renal support (i.e., haemofiltration or dialysis) with the backup of intensivists and nephrologists. Finally, some centres have successfully applied ECCO₂R to reduce the risk of NIV failure in severe chronic obstructive pulmonary disease (COPD) exacerbations and other chronic lung diseases [13, 15, 27].

Admission Criteria

Admission to PICUs and PIMCUs depends on the following factors: (1) the level of intensity of care provided by the facility; (2) the task of the unit carried out in the clinical governance of ARF in the setting of the hospital or healthcare facility in which it is located (step-up from general wards and emergency medicine, step-down from general ICUs, and weaning centre); and (3) the team's

Fig. 2. Schematic representation of PICU and PIMCU location and model. Rectangles represent units with beds and nursing staff (nurse/patient ratio per work shift). GICU, general ICU; PICU, pulmonary intensive care unit; PIMCU, pulmonary intermediate care unit; PW, pulmonology ward.

experience in dealing with increasing levels of complexity of respiratory failure with NIV and invasive ventilation techniques.

Currently, there are no definitive guidelines on admission criteria to PICUs and PIMCUs; the admission criteria should be closely linked to the definition of the level of care and clinical management background of ARF [28] (Tables 2, 3). Moreover, each admission should be assessed on an individual basis, taking into account underlying disease severity and the patient's wishes or advance directives regarding life-support therapy.

Discharge Criteria

Direct discharge from a critical care setting into the community represents a controversial transition for patients [29]. The decision-making regarding readiness for discharge is complex; as soon as the patient's clinical conditions are stable, the treatment process should be transferred to units with a lower intensity care (general wards) or prolonged weaning centres, where they can receive functional assessments and rehabilitation before returning to the community.

The criteria suggested for discharge from PICUs and PIMCUs are as follows:

- Stable physiological status without any need for continuous cardiorespiratory monitoring.
- No fever.
- Complete or partial weaning from invasive mechanical ventilation with a stable respiratory status.
- Stable haemodynamic conditions (absence of uncontrolled arrhythmias, heart failure, or need for intravenous inotropic therapy).
- Stable pulmonary gas exchanges for at least 24 h.

Once the patient meets the discharge criteria, in agreement with the patient and/or the caregivers, the appropriate time for

transferring the patient to a ward or another structure (rehabilitation facilities, weaning centre, long-term ward, or protected residences) will have to be planned according to the clinical conditions, care needs, and social requirements. A direct transfer from a PICU to home should be reserved for specific cases where the patient and/or caregivers are strongly motivated and adequate care and support is available at home.

For tracheostomized patients, when possible, decannulation should be performed before discharge. Patients with ARF failing multiple attempts at weaning from mechanical ventilation ("chronic ventilator-dependent patients") require long-term ventilation.

In the case of discharged tracheostomized patients requiring periodic aspiration and/or mechanical ventilation at home, the patient and caregivers should have been given appropriate training, which must be demonstrated by a written report of the training activities actually carried out in the PICUs and PIMCUs. Last but not least, these units play a pivotal role in telemonitoring programs for ventilator-dependent patients [30].

Organizational Model

There are no guidelines or standards on the best location and design of PICUs and PIMCUs within the hospital [9]. Local considerations, including demand, ICU and ward case-mix, ICU volume, available staffing, and physical and financial resources, represent the key factors for the allocation of the PICUs and PIMCUs in real practice. Several models for the location of these units in a hospital have been proposed: independent location (free-standing unit), parallel model (adjacent to the ICU or colocated), and integrated model (within the ICU or in a Pulmonology Unit, functionally and ideally integrated with a sleep disorder laboratory) [31–34] (Fig. 2).

Locating PICUs or PIMCUs in a Pulmonology Unit and Sleep Disorder laboratory facilitates the integration of respiratory support, the monitoring of breathing resources, and the availability of an experienced team for both acute conditions and chronically ill patients needing titration of home mechanical ventilation (invasive ventilation and NIV). The integrated model in a Pulmonology Unit, adjusting treatment to the patient's needs in the same area, may ensure optimum continuity of treatment; furthermore, the costs of basic equipment per bed and personnel management (nurse to patient ratio) are lower than the integration model in an ICU.

There is no definitive scientific evidence on the recommended number of beds or size of PICUs and PIMCUs. These units should be based on a model of 4–8 beds in the Thoracic or Cardiothoracic Department or elsewhere, depending on the organizational level of the various local situations.

The optimal number of beds reported is as follows: (a) 4–6 for hospitals with >500 beds, (b) 8 beds for hospitals with >1,000 beds, or (c) 1–2 beds per 100,000 inhabitants [10]. The architectural and logistical characteristics of the PICUs and PIMCUs are listed in the online suppl. material (for all online suppl. material, see www.karger.com/doi/10.1159/000516332).

Professionals and Training

Professionals

The teams working in the PICUs and PIMCUs should include professional figures with a variety of skills. The personnel should consist of doctors, such as pulmonologists experienced in respiratory intensive care and airway management, and non-medical staff, such as nurses and respiratory physiotherapists; furthermore, the support of a clinical reference pharmacist is also desirable [35, 36]. In Italy, the minimum mandatory staff (clinicians, nurses, physiotherapists, and social healthcare operators [SHOs]) for the various levels of care is defined by regional and internal hospital regulations.

Professional Nurses

Adequate nurse staffing improves the quality of care and outcome of critically ill patients [37]. However, the optimal nurse to patient ratio in an ICU has not been fully established; this ratio is generally reported as 1:1 or 1:2.

In PICUs, the nurse/patient ratio per work shift must be >1:3 calculated according to a bed/nursing unit/time per shift longer than 480 min [10]. In PIMCUs, the nurse/patient ratio per work shift must be 1:3 or 1:4 calculated according to a bed/nursing unit/time per shift ranging from 360 to 480 min [10]. It is important for nurses to have specific knowledge and skills in critical care, NIRS, airway management, analgesedation, interventional procedures, and monitoring [38].

Respiratory Physiotherapists

The optimal physiotherapist to patient ratio should be 1:6 per work shift dedicated in the unit. Ideally, physiotherapists with dedicated training and expertise in critically ill patients should be available on a 7-day/week and 12-h/day shift basis [39–44].

Qualified Social Healthcare Operator

SHOs represent professional auxiliary figures. There is no evidence for providing recommendations on the specific SHO/patient ratio. They carry out support tasks for nursing care, such as

the delivery of biological materials for laboratory examinations, sterilization of clinical instruments, management of the material warehouse, and patient mobilization.

Medical Staff

The task force of the Society of Critical Care Medicine (SCCM) reports that there are currently no data available for providing recommendations on the specific intensivist/patient ratio [45, 46]. However, it has been reported that a large number of patients per intensivist (1:15) is associated with a negative impact on patient care, especially in terms of days of hospitalization in intensive care [47].

In Italy, the workforce of medical staff in healthcare facilities lies within the responsibility of the regions, which, in turn, leaves the regulation of the internal organization to the individual healthcare facilities. PICUs require the presence of at least one exclusively dedicated doctor 24 h a day for a module of beds ranging usually from 4 to 8 [9–11]. In PIMCUs, the doctor must be immediately available in the ward 24 h a day, but he/she may also be responsible for ordinary hospital beds in the Pulmonology Unit (Table 1) [9, 11]. The medical staff of PICUs and PIMCUs must be made up of pulmonologists experienced in respiratory intensive care, also familiar with airway and cardiopulmonary emergency management, mechanical ventilation, interventional procedures (i.e., bronchoscopy and pleural drainage), analgesedation, and all those other activities that the ERS HERMES (Harmonising Education in Respiratory Medicine for European Specialists) project specifically identifies [48].

Staff Training

There is a growing need for doctors and nurses with acute care skills to manage ARF patients, as demonstrated by the recent global health crisis due to the COVID-19 pandemic [49]. In Italy, unlike the situation in North America and UK, pulmonologists have not been involved with formal recognition in critical care medicine [50, 51]. However, there are some specific requirements that more closely concern the activity of the pulmonologist working in the PICUs and PIMCUs for ensuring correct and safe management of critically ill patients, and these include the main cardiopulmonary resuscitation manoeuvres and airway management. The knowledge and skills of pulmonologists dealing with respiratory critical care and working in PICUs and PIMCUs [48] are divided between necessary and desirable [11], as reported in Table 4.

Furthermore, for the various operators (doctors, nurses, physiotherapists, and SHOs) working in the PICUs and PIMCUs, in addition to technical knowledge and skills, it would be desirable to implement internal training courses and the management of critical issues through training programmes and local simulation to improve and acquire the so-called “non-technical skills,” such as communication between the various team members, leadership roles, the correct use of available resources, and the allocation of tasks [49, 52].

Staff Organizational Requirements

Advance team-based care is essential to improve ICU performance and teamwork. In addition to staff expertise, some specific aspects and skills including availability of appropriate equipment, quality of leadership, and organizational culture are essential to promote safety [52–56].

Table 4. Knowledge and skills required of the pulmonologist

Necessary knowledge
General principles of respiratory medicine
Sleep disorders
Physiology and respiratory pathology applied to mechanical ventilation
Diagnosis and treatment of all forms of acute and acute-chronic respiratory failure
Cardiovascular, renal, and neurological disorders
Neuromuscular disorders
Metabolic and endocrine effects and disorders in critically ill patients
Obesity and related problems
Main infectious diseases
Use of devices associated with oxygen therapy
Inhalation therapy and airway humidification
NIV
Invasive mechanical ventilation
Airway management and endotracheal intubation
Monitoring in spontaneous breathing and during mechanical ventilation
Weaning techniques and factors that hinder weaning
Tracheostomy management
Enteral and parenteral nutrition principles
Delirium, pain, and agitation in the critically ill patient
Pharmacological principles and mechanisms of action of sedative and analgesic drugs; scores and rating scales in the conscious and unconscious patient
Antithrombotic prophylaxis and anaemic states
Prevention of gastric bleeding
Reconditioning of respiratory and skeletal muscles
Evaluation of neuropsychological functions
Human resource management
Communication techniques
Ethical issues and educational programmes
Necessary skills
Airway management
Mechanical ventilation and weaning programmes
Use of prognostic index scores
ECG, non-invasive haemodynamic and respiratory monitoring
Arterial catheter placement
Oximetry, use of transcutaneous devices
NIV during bronchoscopy
HFOT
Bronchial aspiration
Airway obstruction
Thoracentesis
Insertion of a central venous catheter
Insertion of a gastric nose tube
Chest drain insertion
Use of infusion pumps
Tracheostomy tube removal
Cardiopulmonary resuscitation
Management of sedation, pain, delirium, and agitation
Principles of swallowing/speech rehabilitation
Prescription of physiotherapy programmes
Assistance and interviewing of family members
Organization of continuity assistance and home-care programmes
Management and communication in end-of-life care
Desirable skills
ECCO ₂ R
CRRT

NIV, non-invasive ventilation; ECCO₂R, extracorporeal CO₂ removal; HFOT, high-flow oxygen therapy; CRRT, continuous renal replacement therapy.

PICUs and PIMCUs must comply with various organizational requirements:

1. The organizational chart of medical and nursing staff must be correlated with the type and volume of the activity performed and the interventions carried out by the unit.
2. There must be internal regulations and guidelines for carrying out the main activities in agreement with the professional organizational structures concerned, including the protocols for accessing the ward itself.
3. The organization of the work must include procedures for providing adequate responses to both routine requests and emergencies urgencies and the ability to scale up services in response to a natural disaster or pandemic outbreak.
4. Specific procedures to be followed in case of malfunctioning of the medical devices and gases must be provided.
5. Staff meetings should be systematically planned in order to discuss difficult cases and ethical decision-making, to provide training needs, share protocols, and organization of the unit.

Moreover, infection is an important aspect to take into account in the organization of PICUs and PIMCUs. All patients “should be in virtual isolation”; single rooms (with both negative and positive pressure as needed) are strongly recommended to minimize cross contamination [44, 49, 54, 57–59]. A detailed list of design and technical requirements for PICUs and PIMCUs is provided in the online supplementary material.

Economic Aspects and Outcome

Economic Aspects

It has been shown that about 40% of the patients admitted to ICUs never receive active intensive care, including mechanical ventilation, and therefore may be considered ideal candidates for specialized intermediate respiratory care units [9]. It is difficult to calculate the management costs of PICUs and PIMCUs due to the scarce availability of tools for evaluating the workloads of the personnel employed in the various operational settings. An important aspect of the activity is the scarce remuneration of hospitalization based on the DRG (diagnosis-related group) system and the concomitant limitation of resources allocated [60–63]. The current application of the DRG system for the evaluation of the healthcare activity carried out in PICUs and PIMCUs greatly underestimates the consumption of the resources employed compared to the healthcare requirements of the cases treated. Even though the costs for the management of acute-on-chronic respiratory failure are lower in a PIMCU than in a general ICU [64], the DRG system penalizes the reimbursement for NIV, due to a lack of formal recognition of the “weight” of NIV [62] and other new techniques, such as HFOT and ECCO2R, in the coding of the interventions performed for the treatment of ARF and acute-on-chronic respiratory failure.

The potential improvement in efficiency associated with the availability of PICU/PIMCUs and the simultaneous reduction in the medical nursing staff/patient ratio have been emphasized as elements capable of determining a reduction in the cost management of patients with ARF. Indeed, studies on in-depth economic analysis are still extremely scarce, and their conclusions are conflicting [65, 66]. However, it has been reported that admission to a PIMCU of patients with severe exacerbated COPD gives outcomes similar to those obtained in the general ICU but with lower management costs attributable mainly to the setting, ventilation therapy, and non-invasive cardiorespiratory monitoring [64].

Outcome

Although there are theoretical assumptions to support the improvement of the outcome of patients with ARF following the introduction of PIMCUs, the studies published on this topic are relatively scarce, in most cases retrospective and at times contradictory [67–69]. It has recently been reported that the opening of a PIMCU in a general hospital is associated with an improvement in the prognosis of patients with ARF, exacerbation of COPD, or community-acquired pneumonia in terms of a reduction of in-hospital mortality, the need for admission to the general ICU, and the length of the hospital stay [70].

These results can be explained by the appropriate and timely use of NIV, made possible by the presence of an expert and dedicated personnel as well as the availability of monitoring resources, dedicated respiratory physiotherapists, and a concentration of specialist cases. Nevertheless, taking into account the somewhat contradictory results of the reported studies, the lack of shared criteria for admission to the general ICUs and PICUs/PIMCUs, and the risk of a further increase in hospital spending, some intensivists-anaesthesiologists have proposed the placing of intensive and intermediate therapy beds in the same area as the most efficient organizational solution. This could allow for the concentration of expensive equipment, as well as greater flexibility in the use of the beds and the medical nursing staff [71]. A recent Italian study has shown that using NRS is feasible and associated with favourable outcomes in patients with severe ARF ($\text{PaO}_2/\text{FiO}_2$ 152 ± 79) due to SARS-CoV-2 infection treated in newly developed dedicated COVID respiratory monitoring and respiratory intermediate care units with experienced staff [22].

The COVID-19 pandemic has led to huge sustained demand for critical care beds. In late February 2020, the Italian government delivered a directive to regional health authorities to increase their ICU capacity by 50% and to double the number of “pneumonia beds” within a few weeks. More than 10,000 patients had been treated and discharged from Italian Pulmonology wards. Of these patients, 42 were treated with NIV (82% in full pandemic) and 17% with invasive mechanical ventilation [72]. The PICUs/PIMCUs have played a strategic role in linking the activity of general ICUs with lower intensity wards. The general mortality of COVID-19 patients hospitalized in Italian Pulmonology wards was 12% in the first wave of the pandemic, and 22% of patients were transferred from a general ICU (step-down), while only 11% were transferred from PICUs/PIMCUs to a general ICU (step-up) [72].

Conclusions

This document provides an organizational framework and detailed recommendations for the planning of PICUs and PIMCUs that need to be adapted to local conditions and the ever-changing dynamics of health care. The number of critical care beds, trained staff, and technological resources has not been enough to meet the continuously growing demand both in Italy and worldwide as demonstrated in the recent pandemic. Intensive care units and intermediate care units have become necessary to provide optimal care and contain the SARS-CoV-2 pandemic

with an unexpected modification at Italian hospitals in which pulmonologists have played a central role.

The purpose of this position paper is to promote better management of ARF and the resources available in health care. Further research on the use of PICUs/PIMCUs and its effects on hospital outcomes is however necessary.

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Statement of Ethics

This paper did not require ethics approval.

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T.R., R.S., N.A., and A.V. have no conflicts of interest to disclose. A.C. declares that he has financial relationships with Linde.

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Conception: T.R., R.S., and A.C. Drafting the work: T.R., R.S., A.C., and A.V. Critical review of the manuscript: N.A. All authors improved and approved the final version of the manuscript.

Collaborators

Scientific Group on Respiratory Intensive Care of the ITS-AIPO: Arcaro G., Baglioni S., Brunetti G., Carlucci A., Carlucci B., Ceriana P., Clini E.M., Eslami A., Galavotti V., Marchese S., Mollica C., Perretta E., Pisani L., Starace A., Vagheggini G., Vianello A., and Vitacca M.

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